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TENDERS.

NAPIER HARBOUR BOARD. NEW ZEALAND.

Tenders are invited for the SUPPLY and DELIVERY c.i.f. and E. Napier Wharf of a STEAM HAMMER for Pile Driving.

Specifications may be obtained from the Board's Agents:—

Messrs. W. & A. McARTHUR, Ltd., 18/19, Silk Street, Cripplegate, London, E.C. 2.

Tenders to reach New Zealand by 8th January, 1923. X 15

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Wednesday, 20th December,

Tenders for the Supply of:— FENCING MATERIALS.

Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 10/- each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG, Secretary.

Offices, 91, Petty France, Westminster, S.W. 1. 5th December, 1922. X 19

ADMINISTRATIVE COUNTY OF LONDON.

SOUTH WESTERN STORM RELIEF SEWER. CONTRACT NO. 2.

Tenders are Invited for the CONSTRUCTION in TUNNEL of an 11 ft. 4 in. INTERNAL DIAMETER SEWER, in iron, of a total length of about 1¾ miles, together with Outlet to the River Thames, Weir Chambers, Tumbling Bays, Side Entrances, etc., in the Metropolitan Boroughs of Lambeth, Wandsworth and Battersea.

The Specification, Form of Tender, etc., may be obtained on application to the Chief Engineer of the Council at Old County Hall, Spring Gardens, S.W.1, upon payment of the sum of £10. This amount will be returnable only if the tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application, and the contract documents may be inspected before the payment of the fee.

No Tender received at the County Hall, Spring Gardens, S.W.1, after Twelve noon on Tuesday, 9th January, 1923, will be considered. The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD, Clerk of the London County Council. W 905

ROMFORD RURAL DISTRICT COUNCIL.

SOUTH HORNCHURCH SEWER. No. 2 SECTION.

The Council invite

Tenders for the Construction of about 1980 yards of 12 in. dia. STONEWARE PIPE SEWER, with branches, manholes, ventilators, and other work incidental thereto in SOUTHEND ROAD, HORNCHURCH, ESSEX.

Drawings, Specification and Quantities can be seen at the Office of Mr. W. J. GRANT, Surveyor to the Council, 16a, South Street, Romford; also at the Office of Mr. WILLIAM FAIRLEY, Consulting Engineer, Parliament Mansions, Victoria Street, Westminster, S.W.

Tenders must be delivered to the undersigned on or before MONDAY, December 18th, 1922.

The Council do not bind themselves to accept the lowest or any Tender.

T. W. A. GREENHALGH, Clerk to the Council.

16a, South Street, Romford. December 2nd, 1922. X 7

THE BURMA RAILWAYS COMPANY, LIMITED.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply of:—

BOLTS, NUTS and RIVETS (Cwts. 1250, and No. 16,500).

For each copy of the Specification, a fee of 10s. will be charged, which fee is not returnable.

Tenders enclosed in sealed envelopes endorsed "Tender for Bolts, Nuts and Rivets" must be delivered at the Company's Offices not later than 12 noon on Friday, 15th December, 1922. The Directors do not bind themselves to accept any or the lowest Tender, and reserve the right to divide the order.

By Order of the Board. F. C. FRANKS, Secretary.

199, Gresham House, Old Broad Street, London, E.C. 2. 7th December, 1922. X 48

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the following STORES, namely:—

		Fee for Specification.
No. 1.	Steel Fishbolts, Spikes, &c.	10/-
No. 3.	Points and Crossings ...	10/-
No. 3.	Galvanized Wrought Iron Water Tubes, &c.	10/-
No. 4.	Mild Steel Bars, Sections, &c., for Miscellaneous purposes	£1
No. 5.	Steel Drawbars for Wagons	10/-
No. 6.	Tyre Retaining Rings ...	7/6
No. 7.	Steel Tyres for Carriages and Wagons	10/-
No. 8.	Spare parts for Locomotive Engines	£1
No. 9.	Galvanised Corrugated Sheets, &c.	7/6
No. 10.	Brass, Iron or Steel Screws	10/-
No. 11.	Galvanized Stamped Steel Mortar Pans	2/6

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Steel Fishbolts, Spikes, &c.," or as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 19th December, 1922.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE, Secretary.

Company's Offices, 48, Copthall Avenue, E.C. 2, London, 6th December, 1922. X 41

APPOINTMENTS OPEN.

LECTURER ON THE DESIGN OF ELECTRICAL MACHINERY.

A Lecturer is Wanted for one afternoon a week during term time to lecture to Senior Students on the Design of Electrical Machinery. The salary is £150 per annum.—Apply, in the first instance by letter, to Dr. A. RUSSELL, Faraday House Electrical Engineering College, Southampton Row, W.C. 1. X 8

Engineer Representative WANTED for Manchester Office, must be fully acquainted with Fans and their application, Plenum Heating and Dust Removal. Only live man with good connection and able to get business need apply. Don't waste our time unless qualified as above. State full particulars of experience, salary, etc.—Address, X 42, Offices of ENGINEERING.

Wanted, Traveller, having good experience and thorough technical knowledge of machine tools, gas and oil engines.—Write, TRAVELLER, c/o TAYLER'S, 30, Fleet Street, E.C. X 12

A Junior Engineering Assis- TANT is REQUIRED in the Drawing Office of an important MUNICIPAL UNDERTAKING in the Midlands.

The successful applicant must be a good DRAUGHTSMAN and have had a suitable training in WATERWORKS ENGINEERING AND SURVEYING. Preference will be given to Associate Members or Students of the Institution of Civil Engineers.

Applications, stating age, experience, qualifications, and salary required, together with copies of three recent testimonials, to be sent to W 943, Offices of ENGINEERING.

Lucrative Appointment OPEN in a large shipbuilding and engineering establishment for GENTLEMAN well-known in shipowning circles, having intimate relations with principals, and competent to negotiate contracts for vessels up to the large st and highest class.—Address, stating qualifications and experience, W 901, Offices of ENGINEERING.

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Wanted, in London, FIRST-CLASS MAN to develop sale of fittings for cast iron pipes. Applications wanted only from men who are thoroughly familiar with the cast iron pipe trade from the users' and manufacturers' point of view. Preference will be given to anyone having a connection amongst British pipe users and knowledge of overseas markets. The position offers great scope for development to an energetic capable man who has proved his ability to build up business.—Address, giving full details, salary required, X 10, Offices of ENGINEERING.

Purchasing Department.— One of the largest Engineering and Steel Manufacturing Concerns in the country REQUIRE the services of a real live ENERGETIC GENTLEMAN, full of initiative, to take charge of and re-organise their Purchasing Department.

Applicants must be between 35 and 50 years of age, have had a thorough training in such work, and be of unimpeachable character. They must have previously held a position of responsibility in a leading similar concern, or in the Stores Department of any of the leading Railway Companies.

All applications will be treated in the strictest confidence; copies only of references to be sent.

Applicants must state where their experience has been gained, whether they are fully conversant with the best markets to place business for engineering as well as shipbuilding requirements, and what responsible official of the concern they are with is prepared to recommend them.—Address, W 998, Offices of ENGINEERING.

Constructional Steelwork.— GENERAL MANAGER WANTED to act as Assistant to Managing Director; technical, practical and commercial experience essential; must be fully qualified. Preference given to one having held similar position. State experience fully and salary required (Lancashire District).—Address, X 55, Offices of ENGINEERING.

Well-known Firm of Building Contractors and Engineers REQUIRE competent MANAGER to take entire charge of the Building Department, practical experience essential. State experience fully and salary required in strictest confidence (Lancashire district).—Address, X 54, Offices of ENGINEERING.

A Capable Works Manager REQUIRED for non-ferrous sheet metal works in East. Must be competent Engineer, Toolmaker, Draughtsman, familiar with modern costing methods and capable of handling native labour. Good prospects for right man. State age (not over 32), qualifications and remuneration expected.—Address, X 52, Offices of ENGINEERING.

TUBE AND PIPE TRADE.

Wanted, by an Engineering Firm in London, a DEPARTMENT MANAGER to deal with sales of tube and pipe fittings, to build up new business at home and abroad, and to establish new agencies.

Essentials, a thorough knowledge of the pipe and tube trade, ability to influence business from British users, ability to select and control indoor and outdoor staff, familiarity with every detail of business procedure, negotiation of contracts, appointment of foreign representatives, etc. Those unable to bring forward evidence of undoubted success in a similar work are requested NOT TO APPLY.

Applications will be considered in the strictest confidence and should be made in the first instance to X 11, Offices of ENGINEERING.

Smart Commercial Engineer WANTED, about 30, to sell heavy Pulverizers. Essentials are, good selling record and correspondent and experience with Cement and Fertilizer Works and Collieries. Languages advantageous.—Address, stating salary, when free, &c., X 39, Offices of ENGINEERING.

MADRAS PORT TRUST.

Appointment of Deputy Chief ENGINEER to the Port of Madras.

Applications, in writing, for the above appointment will be received by the undersigned on behalf of the Trustees of the Port of Madras up to the 31st December, 1922. Candidates must have previous practical experience on Dock and Harbour Works, and preferably a knowledge of reinforced concrete design and constructions.

SALARY:—Rs. 1275 per mensem, rising by annual increments of Rs. 50 to Rs. 1675 per mensem, with a house-rent allowance of Rs. 60 per mensem.

The selected candidate will be required to join as soon after the end of January, 1923, as possible. Applicants should forward copies of testimonials, which will not be returned, and also particulars of nationality, education, age, diplomas or degrees, accompanied by a record in chronological order of candidates' training and subsequent experience.

The selected candidate will be required to enter into an agreement for a period of three or five years and will be provided with free 1st class passage for himself to Madras and return passage to England on termination of his agreement, subject to the conditions of his agreement.

RENDEL, PALMER & TRITTON, 12/14, Dartmouth Street, Westminster, S.W. 1. X 31

Wanted, Tool Setters for four spindle Gridley Automatics.—Write, stating experience and salary required to BOX 2256, WILLINGS, 20, King Street, Covent Garden, W.C. 2. X 47

Assistant Civil Engineer or DRAUGHTSMAN REQUIRED for Consulting Engineers' Office in Westminster. Must have good general experience and be expert in designing and detailing reinforced concrete work. Give full particulars of career and state salary required.—Address, X 24, Offices of ENGINEERING.

Draughtsman.—Required, at once, in large Bridge works, Experienced DRAUGHTSMAN, capable of designing and rapid detailing of heavy Bridge work. Good prospects for suitable man.—Address, BRIDGE, WM. PORTEOUS & Co., Advertising Agents, Glasgow. X 53

Wanted, for London, Young ENGINEER DRAUGHTSMAN with good Technical and up-to-date knowledge of Crushing, Screening and Cement Machinery. State age, experience, when free, and salary required.—Write, BOX 616, Advertising Offices, 54, Queen Victoria Street, London, E.C. 4. X 51

Structural Steelwork DRAUGHTSMAN REQUIRED, immediately, accustomed to detailing and designing Steel Frame Buildings under L.C.C. 1909 Act, and general structural work.—Address, stating age, experience and salary required, X 36, Offices of ENGINEERING.

Locomotive Engineer Re- QUIRED with an established connection among Locomotive Superintendents of British Railways and Consulting Engineers of Foreign Railways to push Sale and conduct negotiations for very important improvement for Steam Locomotives.—Address, with full particulars of past experience, age, qualifications, and salary required, etc., X 56, Offices of ENGINEERING.

Wanted, First-class Machine Tool DRAUGHTSMAN for engineering firm in North. Age 28 to 30 preferred. State salary required, and give full particulars of previous experience.—Address, X 27, Offices of ENGINEERING.

Draughtsman. — Wanted a First-class Engineer Draughtsman.—Address, stating experience and salary required, X 49, Offices of ENGINEERING.

Lancashire Firm Requires TWO GOOD DRAUGHTSMEN, accustomed to high-class heavy Engineering work. State age, experience and salary.—Address, X 37, Offices of ENGINEERING.

Draughtsman Wanted. Thoroughly conversant with the design of all classes of Centrifugal Pumps, High and Low Lift. Good opening; progressive if experience suitable.—Address, stating age, experience and salary required, X 33, Offices of ENGINEERING.

Draughtsman, First-class Man, WANTED, used to preparing workshop drawings from original designs; must be fully acquainted with the principles of limits and tolerances for repetition work. Birmingham district.—Address, stating age, experience and salary required, X 25, Offices of ENGINEERING.

Ship's Draughtsman for Yard in the South of England, with experience in calculations and design. State age and salary required.—Address, X 23, Offices of ENGINEERING.

Designer. — Commercial Vehicle Chassis construction. Must be fully versed in current practice and design, works training essential. Birmingham district. State in confidence, age, full experience, and salary required, also when disengaged, in the first instance.—Address, X 6, Offices of ENGINEERING.

Good Draughtsmen specialised in Switchboard work REQUIRED. Must have had good mechanical training. State age, experience and salary.—Address, X 5, Offices of ENGINEERING.

Ship's Draughtsman WANTED, used to light craft work. State experiences in tugs, shallow draft vessels. Knowledge of marine engineering preferred.—Address, X 63, *Courant* Office, Chester. W 902

Wanted, Good Senior DRAUGHTSMEN with layout experience on electrical side of Central Stations. Age, salary, and when disengaged.—Address, W 940, Offices of ENGINEERING.

Draughtsman.—Wanted, for Manchester district, SENIOR LOCOMOTIVE DRAUGHTSMAN, capable of working out structural and running gear of electric locomotives. Knowledge of electricity not essential. Applications to include age, experience, and salary required.—Address, W 952, Offices of ENGINEERING.

Experienced Senior Draughts- MAN for Electrical Machinery REQUIRED with London Firm.—Address, stating experience in full, training, age, etc., W 924, Offices of ENGINEERING.

Wanted, Several First-class DRAUGHTSMEN as leading hands on Switchgear work. Age, salary, experience and when disengaged.—Address, W 918, Offices of ENGINEERING.

CHARACTERISTICS OF 5-KW. ELWELL-POULSEN ARC GENERATOR.

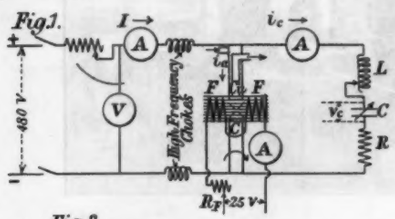
By A. T. C. MOORE, B.Sc.Eng.

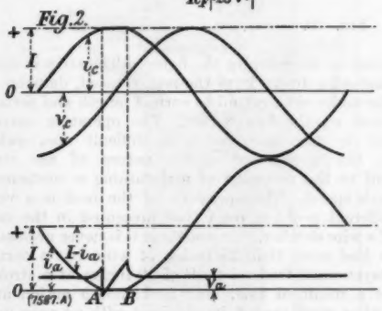
Operation of Arc Generator.—The Poulsen arc, which is now extensively used as a generator of continuous electrical oscillations, depends for its action on the drooping volt ampere characteristic of an arc, as in the Duddell arrangement, and, in addition, the following arrangements due to Poulsen :—

(*a*) Operating the arc between a water-cooled copper anode and a slowly rotating carbon cathode in an atmosphere of hydrogenous vapour.

(*b*) Blowing out the arc by a transverse magnetic field.

The diagram of connections for the arc generator





is shown in Fig. 1, while the arc voltage and current cycle is given in Fig. 2.

The arc cycle.—It is assumed that the D.C. feeding current I is kept constant by the High Frequency (H.F.) chokes, and that the voltage v_c across the condenser C follows a sine-wave throughout the cycle. The sum of the condenser current i_c and the arc current i_a must at any instant be equal to I.

Commencing the cycle with C fully charged in a negative direction, a positive current i_c will flow into it while discharging, and when $i_c = I$ the arc will be extinguished. As i_a decreases the voltage v_a across the arc rises but when the arc is extinguished v_a drops to $v_c + IR$, which will be negative if v_c is greater than IR. From this point v_c increases and v_a, following parallel to it, rises till the arc is again struck. Upon this occurring i_c decreases, following a sine-wave form and leading v_c by 90 deg. during the remainder of the cycle.

Objects of Research and Results.—The tests performed on the generator may be divided into three portions, viz. :—

(i) Distribution of transverse magnetic field in the air gap.

(ii) Effect of magnetic field on the magnitude of the H.F. current.

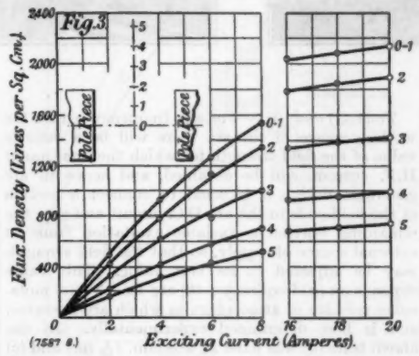
(iii) Relation of wave length to the H.F. current, the generator operating with the field coils FF connected in series with the arc.

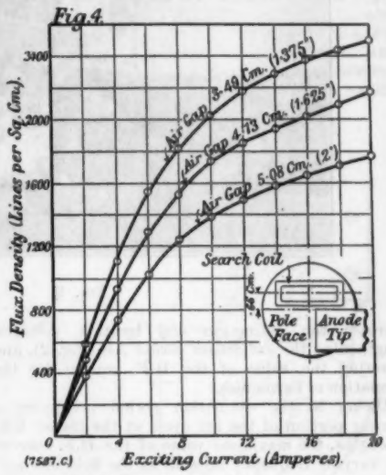
The arc generator was manufactured by Messrs. C. F. Elwell, Limited, and was erected by them at the East London College. It is capable of delivering 15 amperes to the aerial, but, as it cannot be operated on a radiating circuit until official permission has been obtained, a non-radiating circuit was used.

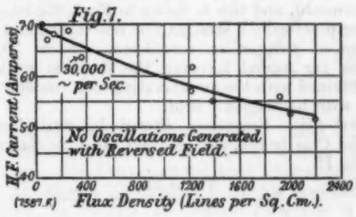
Test (i).—A Grassot fluxmeter was employed to determine the field distribution, the search coil fixed in position between the pole pieces, and the field circuit broken to destroy the magnetic flux, the error introduced by the effect of residual magnetism being negligible.

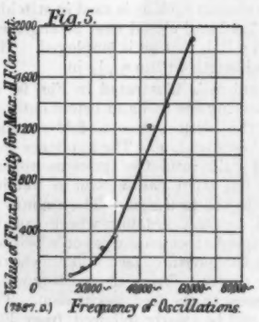
In order to eliminate any creep of the fluxmeter pointer, the mean of a number of readings was obtained, as shown in Table I. The fluxmeter being calibrated in line linkages, the flux density may be found if the number of turns and area enclosed by the search coil are known.

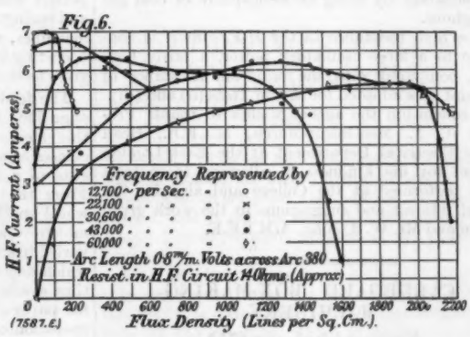
The field coils were separately excited and the field current controlled by a variable resistance Rf in the circuit. Magnetisation curves were also obtained with the search coil fixed in the position where the arc normally operates.











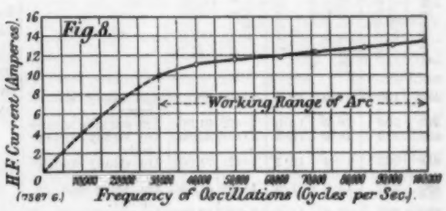


TABLE I.—*Exciting Current, 6 amps. Air Gap Length, 4·13 cm. Height of Search Coil Above Centre Line of Pole, 0·99 cm.*

Deflections Left.			Deflections Right.		
Deflections (Divisions).	Mean "Zero."	True Deflection.	Deflections (Divisions).	Mean "Zero."	True Deflection.
0	—	—	0	—	—
39·9	−0·55	40·45	41·0	0·4	40·6
−1·1	—	—	0·8	—	—
38·8	−1·65	40·45	41·7	1·05	40·65
−2·2	—	—	1·3	—	—
37·0	−3·1	40·1	42·3	1·65	40·65
−4·0	—	—	2·0	—	—
35·5	−5·0	40·5	43·0	2·45	40·55
−6·0	—	—	2·9	—	—
Mean ..		40·38	Mean ..		40·61
Mean of above 8 Readings .. 40·49					

Fig. 3 shows the distribution of the magnetic flux on a vertical plane in the centre of the air gap, and it is seen that the best position in which the arc could operate lies in a vertical distance of 1 cm. on either side of the centre line of the pole pieces, the strength of the field in this part being practically constant. In practice the top edge of the anode tip lies on the centre line of the pole pieces.

The field strength does not fall off very rapidly above the tip of the pole face, owing to the fairly large amount of fringing. The pole pieces are cylindrical in shape in this size of arc generator, although in the larger sizes they are made in the form of truncated cones in order to reduce leakage, and obtain a more intense field in the gap.

The magnetisation curves for various air gap lengths are shown in Fig. 4, the position of the search coil relative to the pole piece and anode tip also being given.

Test (ii).—The frequency of the oscillatory circuit was varied by altering the capacity C and the inductance L in the circuit, and the field current adjusted to various values, observations of the H.F. current and the field current being taken. The wave length, and hence the frequency, was obtained by means of a Sullivan wavemeter.

As the magnetic field is always tending to bow the arc upwards, so lengthening and extinguishing it, the time of extinction will be greatly affected by the field strength. The time available for de-ionising the arc gap is inversely proportional to the frequency, so that a greater field strength will be required with increased frequency, and from Fig. 5 it is seen that the increase in field strength is directly proportional to the frequency between values of 20,000 and 60,000 per second, approximately an additional 500 lines per square cm. being required for each increase of 10,000 cycles per second in the above range. Below 20,000 the arc is unsteady when operating in a magnetic field, and above 60,000 the field is not strong enough to obtain the maximum H.F. current.

The form taken by the curves in Fig. 6 is due to the fact that low values of the field strength cause imperfect de-ionisation of the arc-gap, lowering both extinction and ignition voltages and thus reducing the H.F. current. High field strengths

5-KW. ELWELL-POULSEN ARC GENERATOR.

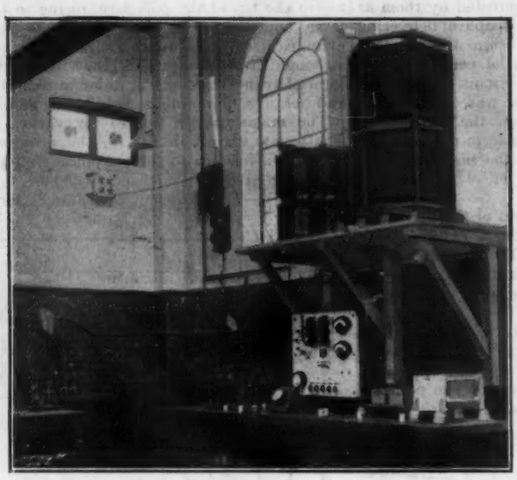


Fig. 9.

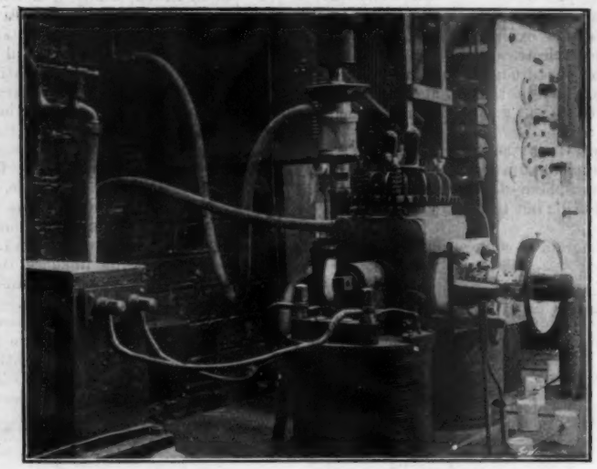


Fig. 10.

increase the extinction and ignition voltages, lengthening the extinction period AB (Fig. 2), and lowering the value of the H.F. current by the formation of harmonics.

Owing to the extinction period occupying a greater portion of the arc cycle at the higher field strengths, the maximum value of the H.F. current for varying frequency falls off as the field strength is increased, and this is shown in Fig 7, the relation being practically a straight line one throughout the range of frequencies considered. Below 30,000 cycles per second however, the steadiest working is obtained with the arc operating as a Duddell arc, *i.e.*, with no magnetic field.

Test (iii).—Frequency altered by variation of L and C as before, and readings taken as shown in Table II.

Table II.

Supply Volts.	Volts across Arc.	Feed Current (Amps.).	H.F. Current.	Ratio Feed/H.F.	Frequency Cycles/Sec.	Remarks.
488	182·5	19·0	13·5	1·408	99,400	Arc steady and silent.
493	200	18·5	13·0	1·422	91,000	Arc working noisily
481	195	18·0	12·8	1·408	83,800	Arc steady and silent.
488	205	17·4	12·2	1·428	71,000	Arc steady and silent.
485	220	17·0	11·8	1·439	61,800	Arc noisy and unsteady.
490	235	16·0	11·6	1·38	49,900	Arc steady and silent.
498	255	15·0	11·1	1·35	40,000	Arc steady and silent.
493	270	13·6	10·0	1·36	30,700	Arc steady and silent.

Table II shows that below 50,000 cycles per second the operation of the arc deviates from that of the normal Poulsen arc in which the ratio of I to i_e is about 1·414. Fig. 8 represents a type of curve obtained in this test showing that at low frequencies the field strength is too great, causing the H.F. current to decrease.

The arc will not oscillate at all below 30,000 cycles per second, owing to the excessively strong field due to the feed current I passing through the field coils.

Conclusions.

Test (i).—Within the working length of the air gap the relation between air gap length and flux density is practically a straight line one, showing that nearly all the reluctance lies in the air gap. In this case the ratio of pole diameter to gap length is about 1, but with larger values of this ratio tapered pole tips must be used and the above ratio becomes an important factor in the design, as it largely determines the cost and weight of the magnetic circuit.

Tests (ii) *and* (iii).—For any frequency within the working range of the arc there will be a definite value of the field strength for which the maximum H.F. current will be obtained, and hence in arc generator design it is usual to connect a section of the field coils in the arc D.C. circuit and give the remaining portion a variable excitation from an external source of supply, so that the field strength may be adjusted to its best value. This value depends on (*a*) frequency; (*b*) arc length; (*c*) molecular velocity of atmosphere in which arc operates, and is best determined experimentally. In the above tests (*b*) was fixed at 0·8 mm. ($\frac{1}{32}$ in.) and (*c*) kept constant by using an atmosphere of coal gas throughout.

As a high resistance in the H.F. circuit is conducive to a large oscillatory power, a fairly high value, compared with the radiation resistance of an aerial, was adopted for this in Tests (ii) and (iii).

In conclusion the author wishes to thank Professor J. T. MacGregor-Morris, M.I.E.E., Head of the Electrical Department at the East London College, for his kindness in allowing these tests to be performed at the College and also for the helpful interest and suggestions in the work given by him and Mr. W. J. John, A.M.I.E.E.

CARDBOARD BOX-MAKING MACHINERY.

(*Continued from page* 671.)

Corner Staying Machines.—It was pointed out in an earlier article that in cases in which boxes are to be paper-covered after they are made up it is undesirable to use a wire-stitched construction, as the wet adhesive by which the paper is secured tends to rust the stitches, with consequent discolouration of the paper and a generally poor effect. This applies particularly to boxes which are likely to be stored. As a consequence of this, boxes which are to be paper-covered are usually stayed at the corners with gummed manilla paper. Such boxes are always made with butted corners, as the gummed manilla strip would not secure an internal flap, and the paper covering would not fold neatly over the edges of a box with internal flaps. A corner-staying machine, of Messrs. Vicker's manufacture, intended for gumming the manilla strip on the box corners is illustrated in Fig. 95 on page 699.

The machine consists of a pedestal with a working head and a treadle control on the general lines of the wire-stitching machines already described. It is power driven, a pulley being carried at the end of the driving spindle at the top of the machine and a clutch being fitted so that the machine may be controlled by the treadle. Gummed manilla paper strip is carried on a reel at the back of the pedestal as shown in the figure. The strip is automatically drawn from the reel, creased, damped on the under side, cut-off to correct length and pressed home on the box corner. The operation carried out by the machine is a difficult one, owing to the tender and sticky nature of the strip and to the necessity of maintaining a continuous high speed. The operation of the feed is a very different problem from that presented in the case of a wire stitcher. In a stitcher it is never necessary to feed more than 2½ inches of wire, but a corner stayer must feed a length of 10 inches at a stroke. As a result of this, long feed smooth action and perfect work cannot be obtained with an open cam and spring return motion such as is used in stitching machines, and a fixed and closed cam arrangement operating through a link motion is employed. This gives feeds of equal length within a $\frac{1}{100}$ in.

The feed mechanism is illustrated in Fig. 96 on page 699. After leaving the reel and before entering this mechanism the strip passes a folder which creases at about its centre line. The appliance consists of a shaped guide and two pressure rollers. From the folder the strip passes over a wetting wheel and thence to the feed gear. The amount of moisture applied by the wetting wheel can be varied to suit the speed at which the paper is passing, which depends on the length of feed and affects the time available for drying. From the wetting wheel the paper strip passes to the feed mechanism. The operation of this will be clearly followed from Fig. 96. The feed carriage, which is shown at *a*, is reciprocated to and fro by the swinging link *b*, which is pivoted to the frame of the machine at its upper end. The strip of paper, which at this stage is in the form of an inverted V is indicated at *c*. A grip, which is shown dotted in Fig. 96, is fitted in connection with the feed carriage. This is linked up to the lever *b* in such a way that when the lever swings to the right, that is in the direction of feed, the end of the grip is pressed into contact with the underside of the paper strip, so that it is held between the grip and the underside of the carriage which is formed to the shape of the strip. The consequence of this is that as the feed carriage moves forward it carries the paper strip with it. On the return stroke, however, the pull of the lever *b* in the reverse direction moves the grip downwards free from the paper, so that the carriage moves back without any backward movement of the paper strip. This gripping arrangement will be understood from Fig. 96, from which it will be seen that an adjustable stop is provided in connection with the swinging grip so that the point at which the paper is gripped can be regulated. The feed carriage travels on a pair of round guides which are not indicated in Fig. 96 but which can be seen in Fig. 95. It will be evident that the link connection between the swinging lever

b and the grip arm allows of the necessary straight line motion of the carriage.

The cam which operates the feed is carried on the main spindle, which runs across the top of the machine. This cam can be seen in Fig. 95, and is indicated at d in Fig. 96. The rotation of the cam causes the oscillation of the lever e, which is pivoted to the frame at its top end. This oscillates the rocking lever f owing to the interconnecting link g, and the rocking lever f in turn oscillates the feed lever b through the action of the connecting link h. The cam is of constant throw, and the purpose of this link mechanism is to enable the feed to be varied although the cam throw is constant. The brief description we have so far given of the operation of this feed link motion does not, of course, explain the feed-adjusting action, and to make this clear we must refer to the action of the anvil bracket i and the feed-adjusting lever k.

The feed is actually adjusted by sliding the anvil

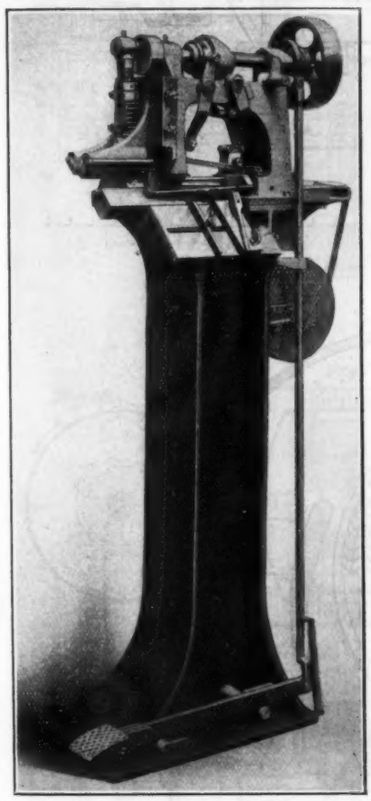


FIG. 95.

endwise so that as the length of anvil projecting from the front of the machine is set to suit the box to be dealt with, the feed is at the same time automatically adjusted to the correct length to suit the same box. The movement of the anvil sets the feed through the action of the bracket i, which is fixed to the anvil. This bracket carries a pin, which engages in the slot formed in the end of the feed-adjusting lever k. This lever is carried on a fixed pivot at its top end, so that as the anvil is slid in one direction, on the other the lever k is moved to a new position and carries with it the block l. The block l slides between fixed guides when the lever k is moved to adjust the feed, but in the normal working of the machine the block is stationary. As will be seen from Fig. 96 the rocking lever f is carried on a second block m which lies end-on to the block l. The second block slides during the operation of the machine, and the action of the block l on this sliding block m determines the feed of the machine.

Our earlier description of the action of the link motion although not inaccurate, was incomplete, and having now explained the arrangements connected with the feed-adjusting lever k we may revert to the operation of the feed. As before explained, the feed is operated by the constant-throw cam d, which imparts a constant-angular motion to the lever e. The movement of this lever oscillates the rocking lever f through the link g. Assuming the mechanism to be in the position shown in Fig. 96 and that the lower end of the lever e begins to move from right to left under the action of the cam the first effect on the rocking lever f will be that it will swing about its upper pin p. This motion will continue until the sliding block m has moved into contact with the fixed block l. When this occurs the pin on the sliding block m becomes a fixed point and as a result the rocking lever f will begin to rotate around its centre pivot and will consequently operate the feed lever b through the link h, and so perform the feed as before described. It will be clear that the amount of feed given will depend on the proportion of the throw of the cam which is spent in moving

Fig. 96.

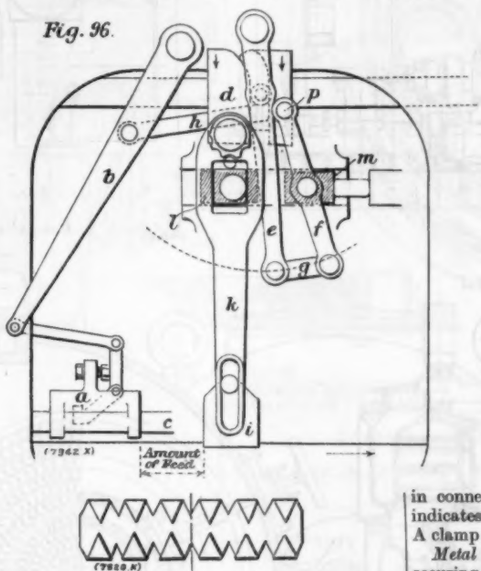


FIG. 98.

the sliding block m and the proportion which is spent in rocking the lever f about its centre. These proportions depend on the position of the fixed block l, and it will be clear that the arrangement gives a feed adjustment in terms of the position of the anvil.

After the formed and wetted strip of paper has been fed forward over the box corner as it lies on the anvil it is pressed into place by the reciprocating head of the machine, which is driven by a disc crank on the end of the shaft as is clearly shown in Fig. 95. The pressure head is connected to its drive through a helical spring so that the gummed paper strip may be firmly secured in place without any necessity for close adjustments to suit the thickness of board from which the box is made. The spring pressure may be adjusted by the nuts to be seen in the figure. It will be clear that when the two box sides are assembled on the anvil for staying it is necessary to butt the two edges together, and that when this work is being done if by any chance the fingers of the operator stray to the top of the anvil they will be crushed when the head descends. This possibility has given the corner stayer the reputation of being the most dangerous machine which the box-maker has to handle. To eliminate this danger in the machine under consideration a pair of guards are fitted. These are indicated at G in Fig. 97, which shows the pressure head of the machine and a box being held in position for corner staying. The guards G are carried on the ends of horizontal rods connected to a reciprocating part of the machine, and as the paper is fed under the pressure head these guards sweep forward over that part of the anvil on to which the pressure head is to descend. In their passage they push any obstruction, such as the fingers of the operator, out of the way as the head descends, and return to their original position as the box corner is released, so that the box may be freely turned corner to corner as is the usual practice. The horizontal rods which support the guards G lie outside the width of the pressure head, and the guards themselves move beyond the end of it, so that they do not interfere in any way with the descent of the head. The rods perform a second function in supporting the front end of the paper strip and keeping its alignment, so preventing crooked staying.

The working speed of a corner stayer is 80 to 90 strokes a minute, giving an output of 960 pieces per hour. Both 6-in. and 10-in. machines are built. The standard machines are built to deal with paper strip 1 in. wide, but strip $\frac{7}{8}$ in. wide may be used with them. If it is desired to use other widths it is only necessary to change the cut-off knife and guide arms, which can be done in a few minutes. The setting of the anvil is operated by a handle

Fig. 97.

in connection with which a scale is fitted which indicates in terms of the box or lid to be dealt with. A clamp is fitted to secure the anvil after setting.

Metal Edging Machines.—A further method of securing, or staying, the corners of boxes is by means of metal strip formed as illustrated in Fig. 98. This type of edging will be generally familiar, and was dealt with in our earlier description of the various classes of boxes. The method is used only for uncovered boxes. The machine which is employed for fixing this metal edging is generally similar to the corner stayer, the strip being carried on a reel at the back of the machine and the feed gear being the same. A compensating arrangement is, however, fitted in connection with the feed so that the cut-off always occurs at a division between the teeth. It will be clear that in the absence of some such provision the cut-off would not long retain its correct position owing to the cumulative effect of any small error in setting the feed, and to the fact that the anvil may not be set at a projection exactly equal to any number of teeth in the edging. The feed is arranged to bring the edging to the cutting position next shorter to the actual depth of the box. Metal edging machines have a working speed of 60 strokes a minute and an output of some 600 pieces an hour.

(To be continued.)

EPICYCLIC REVERSING GEAR FOR LJUNGSTRÖM MARINE TURBINES.

EPICYCLIC reversing gears were fitted many years since to boats driven by internal-combustion engines, but the power transmitted has been relatively small, and it was accordingly a bold step for the Svenska Turbinen Aktiebolaget Ljungström, of Finsborg, Sweden to apply the system on a turbine-driven steamer of 2,150 aggregate effective horse-power. The boat in question is named the Pacific and belongs to Copenhagen owners. She is of 7,400 tons deadweight. Her machinery consists of a Ljungström steam turbine running at 3,000 r.p.m. and designed to operate with steam supplied at a stop valve pressure of 185 lb. per square inch and at a temperature of 662 deg. F.

EPICYCLIC REVERSING GEAR FOR THE TURBINE STEAMER "PACIFIC."

CONSTRUCTED BY THE SVENSKA TURBINEN AKTIEBOLAGET LJUNGSTRÖM, FINSBORG, SWEDEN.

Fig. 1.

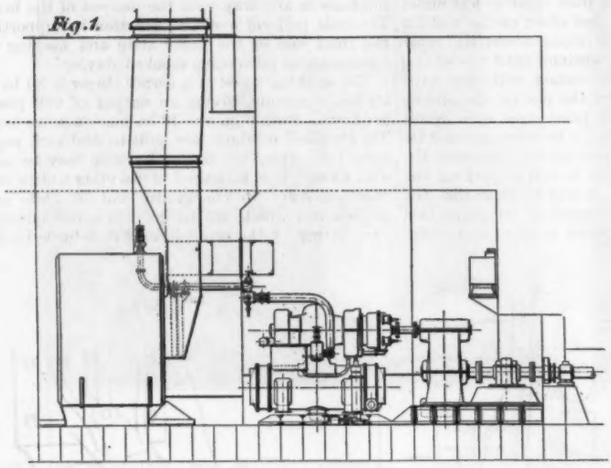


Fig. 2.

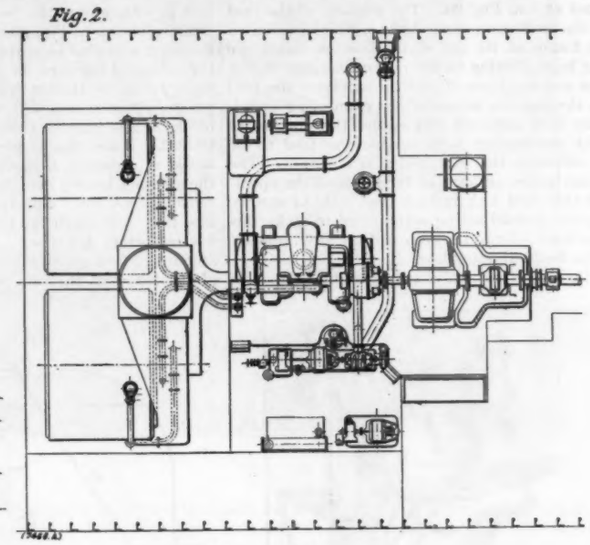


Fig. 3.

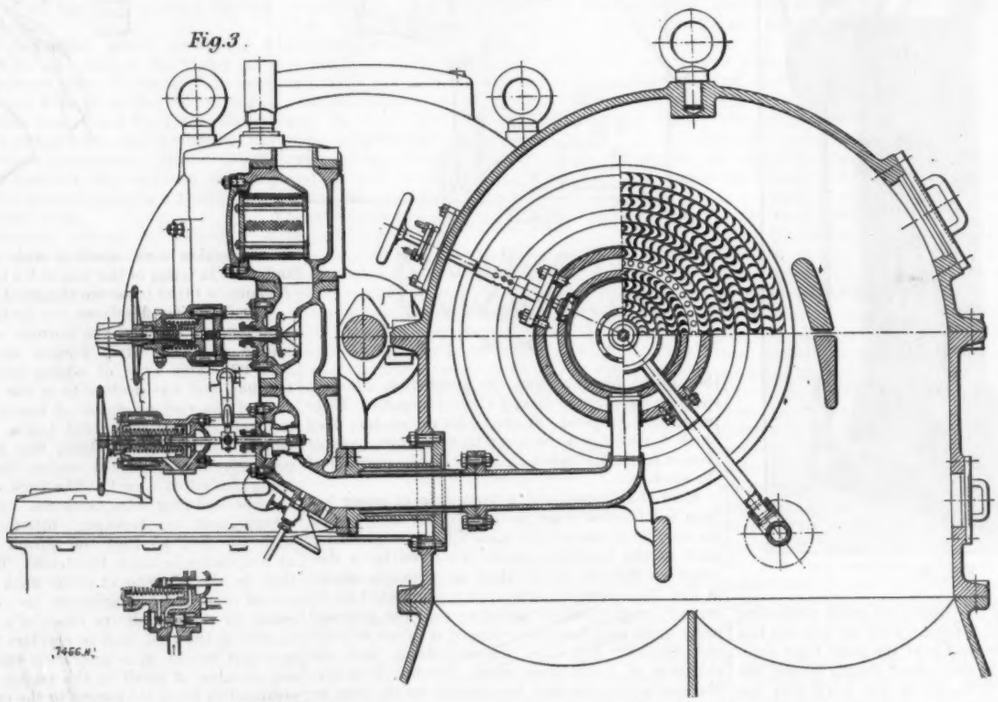


Fig. 4.

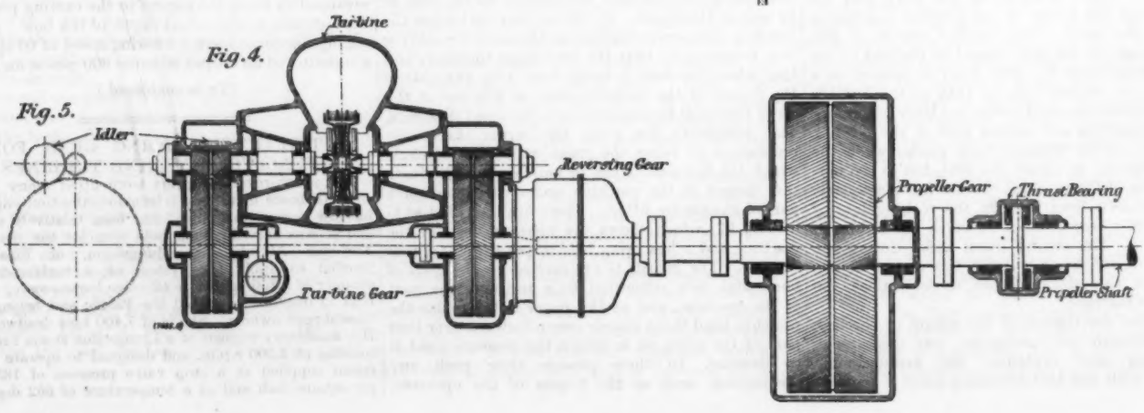
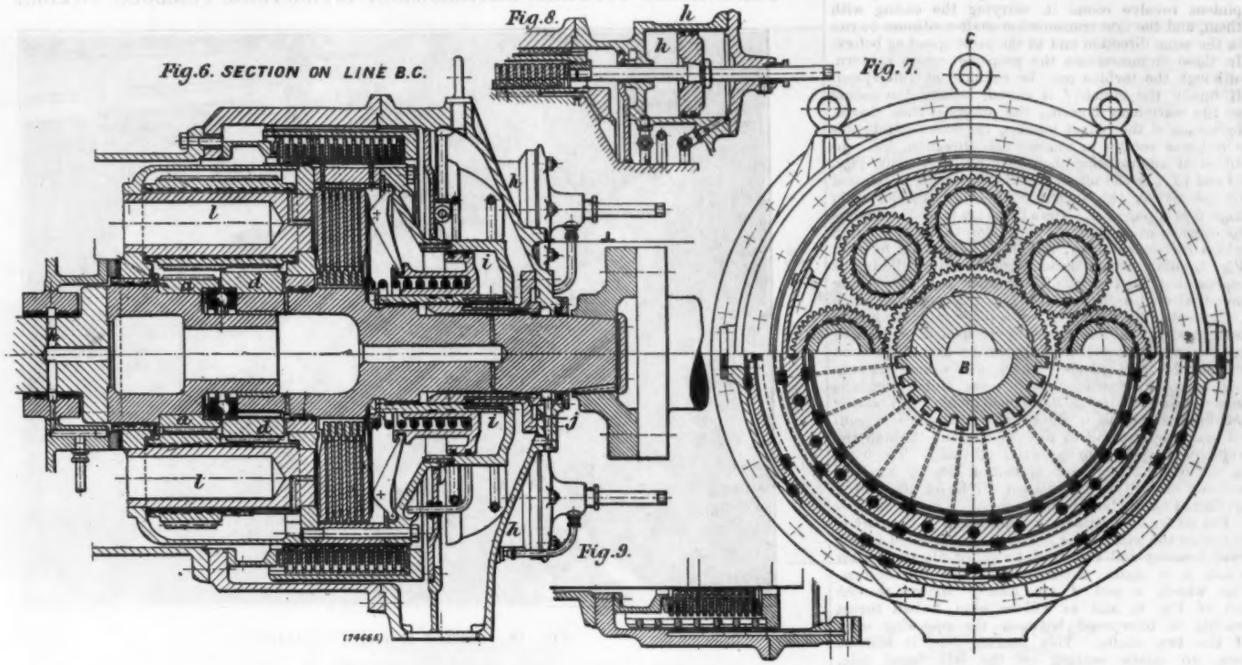
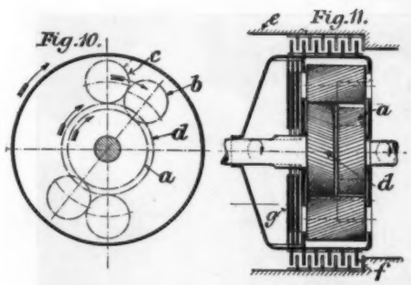


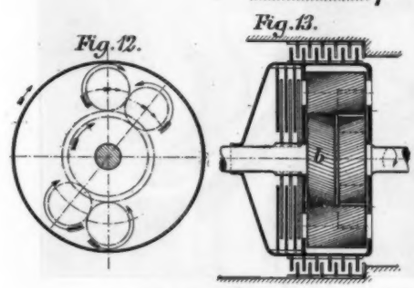
Fig. 5.

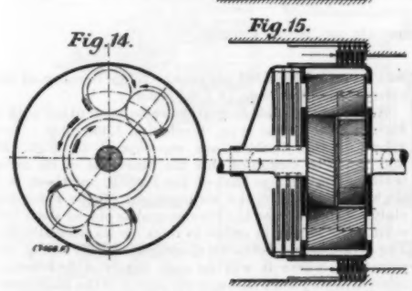
EPICYCLIC REVERSING GEAR FOR LJUNGSTRÖM MARINE TURBINES.

CONSTRUCTED BY THE SVENSKA TURBINEN AKTIEBOLAGET LJUNGSTRÖM, FINSBORG, SWEDEN.









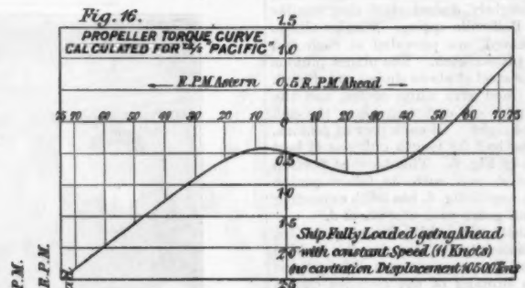
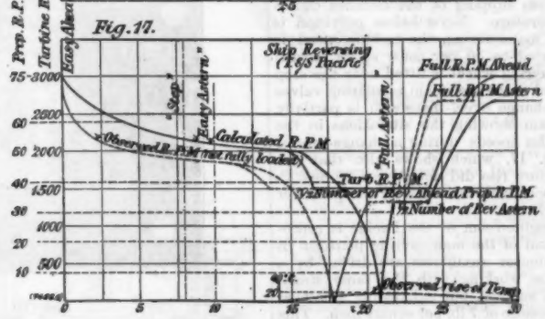


Fig.16.
PROPELLER TORQUE CURVE CALCULATED FOR 12½ "PACIFIC"
R.P.M. Astern
0.5 R.P.M. Ahead
Ship Fully Loaded going Ahead with constant Speed (11 Knots) no cavitation. Displacement 10500 Tons



The general arrangement of the machinery of this vessel is well shown in Figs. 1 and 2.

The special characteristics of the Ljungström turbine are now well known, but it may be well nevertheless to recall that it has two intermeshed rotors turning in opposite directions, and it is always mounted complete on top of its condenser, as is clearly shown in Fig. 1. A cross-section through the two rotors is illustrated in Fig. 3, which shows very clearly that practically the whole of the casing is at the temperature of the condenser, so that the only hot surfaces exposed are those of the valves and steam piping. This arrangement tends to keep the engine room cool.

Which can be locked at will either to a fixed housing or to the second transmission shaft. The pinion c of each pair gears with the wheel *d*, which is mounted on the second transmission shaft. When the propeller is to run in the ahead direction the relative arrangement of the components is as represented in Fig. 11. The multiple plate clutch shown at *f* is then open so that the gear casing can revolve freely within the fixed housing *e*, whilst at the same time a second multiple plate clutch *g* is closed, thus locking the second transmission shaft to the casing. In these conditions there is a solid drive between the first transmission shaft and the second. The planet pinions then simply act as keys between

The general arrangement of the Ljungström turbine is well known, but it may be well nevertheless to recall that it has two intermeshed rotors turning in opposite directions, and it is always mounted complete on top of its condenser, as is clearly shown in Fig. 1. A cross-section through the two rotors is illustrated in Fig. 3, which shows very clearly that practically the whole of the casing is at the temperature of the condenser, so that the only hot surfaces exposed are those of the valves and steam piping. This arrangement tends to keep the engine room cool.

The general arrangement of the gearing is illustrated in Fig. 4, which represents diagrammatically a plan (partly in section) of the turbine first transmission shaft, reverse gear, the second reduction gear, and the thrust bearing of the Pacific plant. Each rotor shaft carries a pinion which drives a double helical gear wheel on the first transmission shaft. As the two rotors turn in opposite directions an idler is interposed between the rotor pinion and the gear wheel as indicated in Fig. 5. In this first reduction the speed is reduced form 3,000 r.p.m. to 540 r.p.m., and this speed is further reduced to 70 r.p.m. in the second reduction gear, which is shown to the right of the reverse gear. Details of this reverse gear are illustrated in Figs. 6 to 9, annexed, but it will, however, perhaps be better understood, after a study of the diagrams, Figs. 10 to 15, also annexed, which show very clearly the characteristic features of epicyclic reversing gears.

The wheel *a* is mounted on the first transmission shaft and gears with the component *b* of several pairs of intermeshed pinions *b* and *c*, carried by a casing

the wheel *a* and the casing, which as stated is clamped by the clutch *g* to the second transmission shaft. If this clutch be now opened we get the condition of affairs indicated in Figs. 12 and 13. The secondary shaft remains stationary, whilst the planet pinions revolve round it, carrying the casing with them, and the first transmission shaft continues to run in the same direction and at the same speed as before. In these circumstances the propeller ceases to turn, although the turbine may be running at full speed. If finally the clutch *f* is closed, locking the casing to the stationary housing, the pinion *a* then drives, by means of the planet pinions, the wheel *d*, but this wheel now rotates in the opposite direction, the condition of affairs being then that represented in Figs. 14 and 15. In the actual gear the clutches are operated by oil relays, the arrangement being as shown in Figs. 6 to 8, page 701. Here there are four oil cylinders to operate each clutch. Those for the outer clutch which corresponds to *f*, Fig. 11, are denoted by *h* in Fig. 6, and a section through one of these cylinders is represented in Fig. 8. These four cylinders being mounted on the fixed housing can be supplied with oil without difficulty. Any oil leakage from the glands is trapped and led inside the outer housing to a common sump for all the oil escaping either from lubricated surfaces or from glands. There is a special oil connection for lubricating this external clutch which is shown separately in Fig. 9. The cylinder for operating the internal clutch is shown at *i*. There is a continuous supply of oil to the inner casing through the shaft by the ports shown to the right at *j*. These are in the fixed casing, and as before, can be supplied without difficulty. The return stroke of the piston is effected by the helical spring shown.

The oil for lubrication purposes enters at the port *k*, shown on the left, and as it escapes is collected in the fixed housing and conveyed away for filtration after which it is again circulated through the system. The wheels *a* and *d* are clearly shown to the left of Fig. 6, and as will be seen, a ball thrust bearing is interposed between the opposing ends of the two shafts. This bearing has, it will be seen, an elastic seating on the left hand side, which consists of a slightly dished steel ring similar to a component of a Belleville spring. Similar elastic cushions, it will be noted, are provided at each end of the outer multiple plate clutch. The planet pinions are mounted on hollow steel studs as shown at *l*, Fig. 6. They are themselves lined with white metal, and the bearing is supplied with oil under pressure through the ports shown to the right. Of each pair of pinions, one has teeth covering half its length only, as is best seen near the bottom of Fig. 6. This toothed portion gears with the wheel *a*, and with its fellow pinion which, as shown at the top of Fig. 6, has teeth extending over its full length and gears with the wheel *d*.

It will be seen that with this arrangement for reversing there is no necessity for stopping the turbine when manœuvring, and the gears are so well lubricated that even continuous slipping of the clutches causes little rise of temperature. Nevertheless provision is made by which in manœuvring, the turbine speed is automatically reduced to 50 per cent. of its normal value; the manœuvring wheel is fitted near the stop valve and is coupled up to the steam regulating valves so that during a change over, the steam is partially shut off. A diagram showing the alterations in the turbine and propeller speeds during a change-over is reproduced in Fig. 17. which shows also that the maximum temperature rise did not exceed 20 deg. C. Fig. 16 shows proportional variations in the propeller torque during the change.

A view of the engine-room of the Pacific is reproduced in Fig. 18, and of the manœuvring platform in Fig. 19. The condenser auxiliaries are driven by a small steam turbine working with the same steam supply as the main engines, but exhausting to a feed heater at a gauge pressure of 7 lb. per square inch. This turbine runs at 15,000 r.p.m., and is geared down in a single reduction to 1,500 r.p.m., which is the speed of the pumps. Other auxiliaries include a direct-current generator which drives the condensate pump, the Howden fan, and supplies the electric light. The ship has two single-ended marine boilers, each with three furnaces, and a heating surface of 2,320 ft. sq. They are fitted with Howden's forced draught and Schmidt superheaters.

At official tests carried out at the "Stal" works by Professor A. Lindfors, the consumption of steam, exclusive of the auxiliaries proved to be 8·33 lb. per shaft horse-power an hour, under the following conditions: Steam pressure at the stop valve, 185 lb. per square inch; temperature 662 deg. F.; 2,097 s.h.p. On the trial trip, which was run at the end of December, 1920, the steamer had a displacement of 4,130 tons, and with 1,727 s.h.p. an average speed of 12·59 knots was attained, with a consumption of 1·07 lb. coal of 12,600 B.Th.U./lb. per shaft horse-power an hour (0·912 lb. per indicated horse-power). This consumption includes coal for all auxiliaries, steam steering gear, steam heating and electric light. During the whole of the trial the machinery worked without a hitch, the good behaviour of the reversing clutch being specially marked. The propeller was reversed from full speed ahead to full speed astern in 27 seconds, and the clutch gear wheels worked so smoothly that it was impossible to tell from the sound which way the propeller was working. The noise of the two reduction gears was far less than ordinary, which was ascribed to the special methods adopted by the Stal Company in the production of spiral cut wheels and pinions.

The S.S. Pacific has been twice to Australia, and has since returned to Denmark from a voyage to Honolulu. The reports from the owners are highly satisfactory. The total consumption of coal per day has been on an average 23 tons for all purposes with the turbines developing about 2,300 i.h.p., or 0·92 lb. of coal per indicated horse-power an hour. Average bunker coals were used, and the percentage of ash was on an average 16¼ per cent. When burning oil the consumption has been 16 tons per day.

A second vessel, T.S. Stal, has also been fitted with a turbine of the same type, developing 1,350 i.h.p. Two views of this turbine are reproduced in Figs. 20 and 21. The design of this machinery is in its main features the same as that of the Pacific, but there is a slight difference in the arrangement of the reversing clutch. In this case the reverse gear is placed abaft the main gear casing in order to increase its accessibility. The arrangement is shown diagrammatically in Fig. 22, page 703, where it will be seen that the first transmission shaft passes through the pinion of the main gear. There are also some minor alterations in the design of the clutches, which, as shown in Figs. 23 and 24, are in this case opened and closed by one and the same relay, consisting of a single cylinder concentric with the shaft axis. The piston of this relay opens and closes the clutches by the six levers shown, and it will be obvious that it is quite impossible for both clutches

EPICYCLIC REVERSING GEAR FOR T.S. "PACIFIC."

THE SVENSKA TURBINEN AKTIEBOLAGET LJUNGSTRÖM, FINSBORG, SWEDEN.

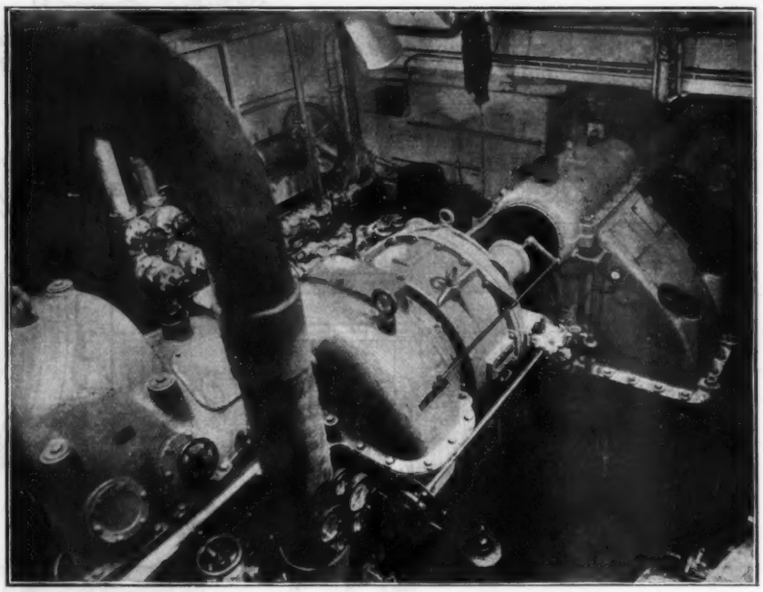


Fig. 18. Engine Room of "Pacific."

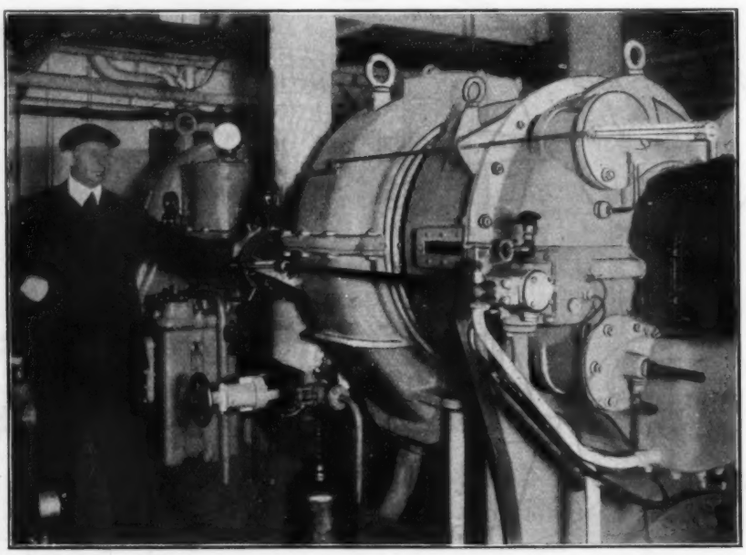


Fig. 19. Manœuvring Platform of T.S. "Pacific."

EPICYCLIC REVERSING GEAR FOR T.S. "STAL."

CONSTRUCTED BY THE SVENSKA TURBINEN AKTIEBOLAGET LJUNGSTRÖM, FINSBORG, SWEDEN.

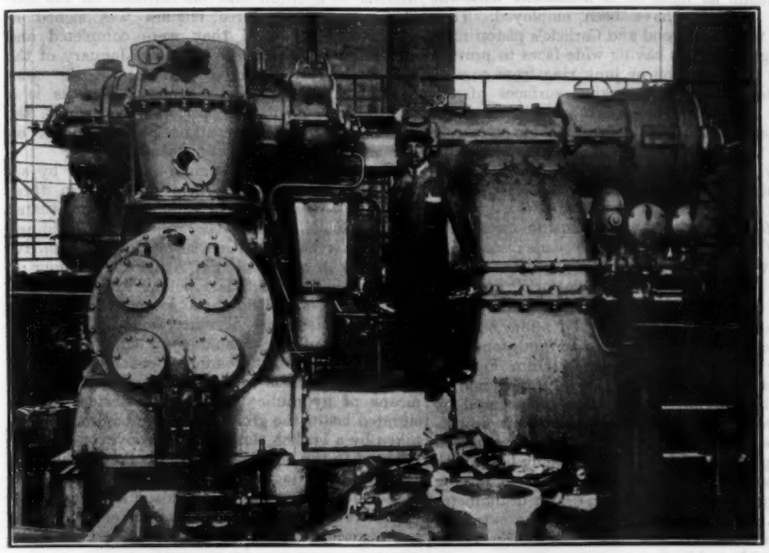


FIG. 20.

FIG. 21.

Fig. 23.

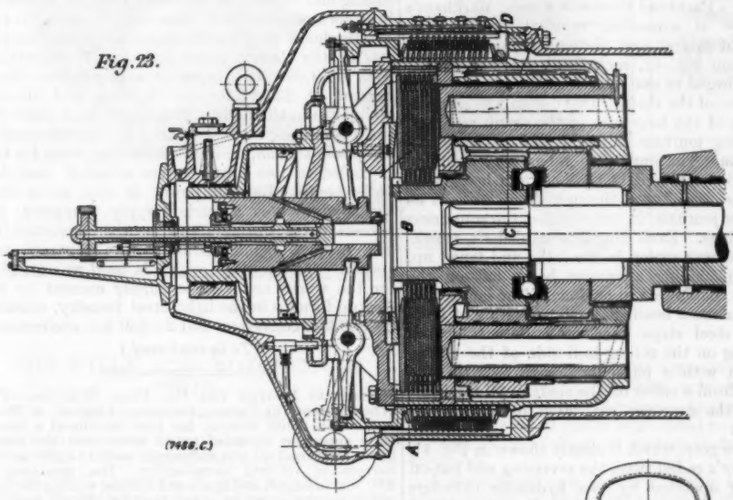
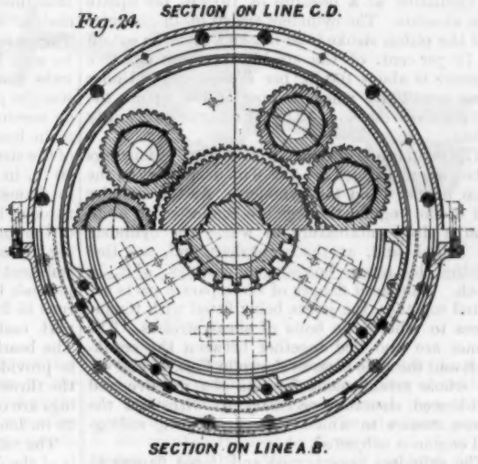
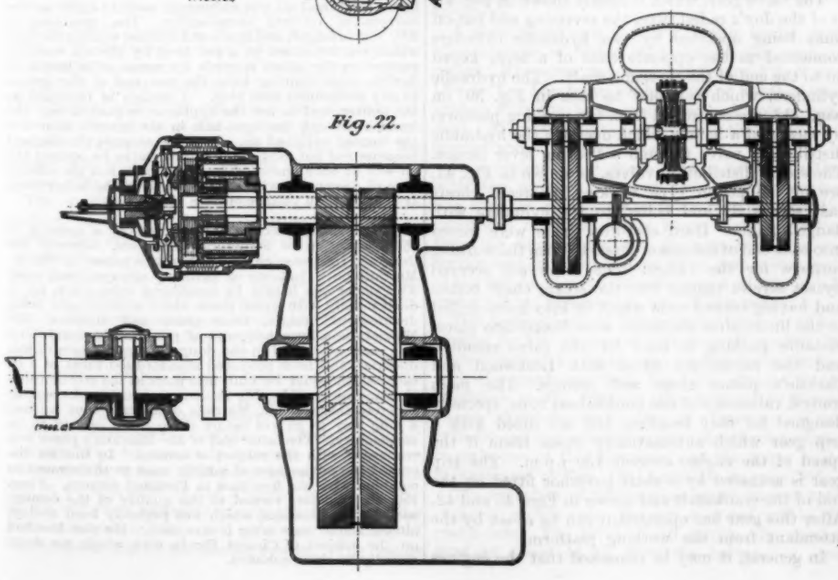


Fig. 24. SECTION ON LINE C.D.



SECTION ON LINE A.B.

Fig. 22.



to be closed at the same time. With this arrangement space is economised more than with that adopted in the case of the Pacific, and an excellent idea of the compactness secured is well indicated by Figs. 20 and 21, on this page, which are reproduced from photographs taken during the erection of the machinery in the builders' shops.

On its official trials the coal consumption of the Stal proved to be 0·92 lb. per indicated horse-power, the coal having a calorific value of 12,900 B.Th.U. per pound.

A third marine set of the same type designed to develop 1,950 h.p. is being fitted to a cargo boat now under construction at the shipyard of Köpenhamns Flydedok, Copenhagen. We are indebted to Mr. O. Wiberg, of the builders' firm, for the particulars of these interesting installations.

EXPLOSIONS OF ORGANIC DUSTS.—Describing his investigation of thermal and electric ignition of dust clouds, especially of sugar, R. Beyersdorfer, of the Frankenthal sugar works, makes a possibly novel suggestion. He found that, when clouds of sugar dust were stirred up in the air, the sugar became positively charged, potentials of 10,000 volts being observed. Most of this charge is lost again by silent discharge, but there may also be sparking and ignition, favoured by ozone formation. Some organic particles have a very strong power of absorbing oxygen; the silent discharge leads to ozonisation of this oxygen, and to the formation also of the nitrogen oxide N_2O_5, and the heating and sparking effects may become sufficiently powerful to ignite the finest dust particles, which spread the flames.

THE MOSSEND STEEL WORKS AND ROLLING MILLS.

(*Continued from page* 643.)

The rolling mills are driven by three separate engines, each of which is capable of developing 12,000 i.h.p. One of the engines drives the cogging mill, another the first and second roughing mills, and the third, the finishing mill; their arrangement is most clearly shown in the general plan reproduced in Fig. 2, on Plate XXXIII, published with our issue of October 13 last. The engines, all of which are identical, were designed and constructed by Messrs. Markham and Co., Limited, Chesterfield, and are illustrated in Figs. 38 and 39, on page 712, and in Figs. 40, 41 and 42, on Plate XLIII, which accompanies this issue. Fig. 38 shows the three engines for Mossend as erected in the builder's shops, while Fig. 39 illustrates the appearance of an almost exactly similar engine in the finished state. This particular engine was actually supplied to another Scotch steel works, and has a crankshaft of somewhat different design from those of the Mossend engines. In all other respects, however, the latter are accurately represented by the illustration.

The design and construction of the Mossend engines can best be followed from the drawings reproduced on Plate XLIII. Of these, Fig. 40 is an elevation of the rear end, Fig. 41 a longitudinal section and Fig. 42 a complete plan. The engines are of the three-cylinder simple, non-condensing type, and are, of course, reversible. They are designed for a working pressure of 160 lb. per square inch, with steam superheated by from 120 deg. to 150 deg. F., and they exhaust into three Rateau heat accumulators at a pressure of 19·5 lb. per square inch absolute. The cylinders are 40 in. in diameter and the piston stroke is 54 in., and with the cut-off at 70 per cent. of the stroke, the mean effective pressure is about 100 lb. per square inch. Under these conditions, when running at 120 r.p.m., the engines each develop 12,000 i.h.p., as previously stated.

The main frame of each engine comprises four legs of box section, which are 5 ft. 6 in. deep between the main bearings and the cylinders. At the cylinder end of the engine, the legs are connected so as to form a deep entablature to which the cylinders are bolted, and, at the crankshaft end, are tied together by heavy box-section castings, 4 ft. in depth. The faced flanges of the separate parts are bolted together, the joints being fitted with tongue pieces to relieve the bolts of shear stresses. The frames are also tied together between the crankshaft and the slide bars, as shown in Figs. 41 and 42, the whole arrangement forming the massive and well-braced structure necessary to withstand the severe stresses to which a large reversing rolling-mill engine is subjected.

The cylinders have turned and faced flanges at the front ends which are bolted to the entablature of the bed frames above referred to. As shown in Fig. 41, a spigot on the cylinder flange fits into a bored recess in the flange of the entablature, so as to ensure accurate alignment. It may be of interest to mention that the flanges of the bedplate were bored and faced in one operation on a large floor boring machine after the bed had been completely assembled, lined up and bolted together on the floor of the machine shop. The outer ends of the cylinders are not bolted down to the bedplate, but are supported by feet resting on machined seatings formed on extension pieces to the main frames, as shown in Fig. 41, so that the cylinders are able to expand and contract freely. The extension pieces, it will be noticed, are continued outwards from under the ends of the cylinders so as to form supports for the tail-rod slides. The front ends of the cylinders are cast with the body, but a small cover forming the front stuffing-box was fitted in each case to close the opening left for the boring bar. Deep, well-ribbed covers, the design of which is clearly shown in Figs. 40 and 41, are provided for the rear ends. The piston rods and tail rods are packed with metallic packing, and to reduce as far as possible the tendency for the pistons to wear the bottoms of the cylinders, long bushes lined with white metal have been introduced into the design of these packings to support the weight. Moreover, the piston rods and tail rods have been made 9 in. and 8 in. in diameter, respectively, in order to reduce deflection. For the same purpose, cast steel pistons, made as light as is consistent with the necessary strength, have been employed. They are fitted with Lockwood and Carlisle's piston rings and springs, the rings having wide faces to prevent the edges of the piston or junk ring from coming into contact with the working surfaces of the cylinders. Although they are supplied with superheated steam, particular care has been taken in designing the engines to provide adequate drainage for the cylinders, owing to the fact that comparatively long standing periods are sometimes unavoidable when waiting for ingots. Each cylinder has therefore been fitted at the bottom with large open-type relief valves at both ends; some of these valves are shown in Fig. 40. Draincocks operated from the working platform are also provided.

The connecting rods measure 11 ft. 3 in. between the centres of the crank-pins and gudgeon pins, and their design can be followed from Fig. 41. The big-ends, it will be seen, are of the marine type, while the gudgeon pin steps are secured by bolted straps and have wedge and screw adjustment; the steps for both crank pins and gudgeon pins are of gun-metal, the former being lined with Babbitt metal. The crosshead is a steel forging with a forged-steel gudgeon pin, 9½ in. in diameter and 11 in. long, shrunk in, the pin being extended on each side to take the slide blocks; the latter are 12 in. wide and 30 in. long.

The crankshafts, which were made at Messrs. Beardmore's Parkhead Works to Messrs. Markham's design, are of somewhat unusual construction. They are of forged steel throughout, and, as will be seen from Fig. 42, each crank-pin and pair of webs was forged in one piece and shrunk on to the straight part of the shaft. This design was adopted on account of the large size of the crank pins and main bearing journals in proportion to the length of the stroke. The crank-pins, we may mention, are 20 in. in diameter and 13 in. long, and holes 4 in. in diameter were bored through them, as well as through the journals, in order to test the soundness of the forgings. Each complete crankshaft, weighing 27 tons, was swung in the lathe and trued up, sufficient machining allowance being left on the journals to enable this to be done. The crankshaft runs in four main bearings, each consisting of four-part cast steel steps lined with Babbitt metal. The bearing on the rolling-mill side of the engine is provided with a phosphor-bronze face to take the thrust from a collar on the shaft. All the bearings are of the same size, viz., 20 in. in diameter by 26 in. long.

The valve gear, which is clearly shown in Fig. 41, is of the Joy's radial type, the reversing and cut-off links being operated by two hydraulic cylinders connected to the opposite ends of a lever keyed on to the end of the reversing shaft. The hydraulic cylinders, which can best be seen in Fig. 39, on page 712, are controlled from the working platform by means of a handle which operates the hydraulic distributing valve through a floating lever device. The steam distribution valves, as shown in Fig. 41, are of the piston type working in steam chests cast separately and bolted to the cylinders with flanged joints. Hard cast-iron liners were forced into each end of the steam chests to form the working surfaces for the valves. The liners are secured by set screws tapped into the steam chest bodies and having turned ends which fit into holes drilled in the liners after the latter were forced into place. Metallic packing is used for the valve spindles, and the valves are fitted with Lockwood and Carlisle's piston rings and springs. The main control valves are of the double-beat type, specially designed for easy handling and are fitted with a trip gear which automatically closes them if the speed of the engine exceeds 130 r.p.m. The trip gear is actuated by a shaft governor fitted on the end of the crankshaft and shown in Figs. 40 and 42. After this gear has operated, it can be re-set by the attendant from the working platform.

In general, it may be remarked that the engines are of massive proportions, with a liberal margin of strength, and have been provided with ample bearing surfaces to enable them to run for long periods with a minimum of attention. The total weight of each set is 250 tons. It may also be of interest to mention that the contract for the construction of the three engines was signed in February, 1917, and they were completed and assembled as shown in Fig. 38 by January of the following year. Their construction in the comparatively short period of eleven months is a particularly creditable performance when the difficult conditions prevailing at that time, on account of the war, are borne in mind.

Steam for all three engines is supplied by six Babcock and Wilcox boilers arranged in three batteries of two each in a boiler-house situated on the south side of the rolling-mill buildings. Each boiler has a heating surface of 5,346 sq. ft., and gives an evaporation of 20,000 lb. per hour on mechanical draught. The boilers are fitted with superheaters and Underfeed stokers, and Green's fuel economisers are also installed. A supply of coal, sufficient for 72 hours working, is stored in overhead bunkers, of reinforced-concrete construction. The coal is emptied from the trucks, by means of hydraulic tippers, into a steel hopper situated below the ground level, and from this it is taken by a bucket elevator and conveyor and distributed to the bunkers over the boilers. The ashes are dropped through hoppers in the floor of the boiler-house into bogies in the basement and are transferred from these, by means of an electric hoist, to an overhead bunker, whence they can be dumped into railway wagons for removal.

As previously mentioned, the exhaust from the rolling-mill engines is delivered into three Rateau heat accumulators, and these supply steam to two Westinghouse mixed-pressure geared turbo-generator sets in the electric power station. These sets are each of 1,000 kw. capacity and produce direct current at 220 volts for lighting and driving auxiliaries in the mills. The condensing plant for the turbo generators is placed in the basement of the power station, and the circulating water for this is cooled in two large towers situated near the boiler-house. Electric power is also taken from the Clyde Valley Electric Supply Company, the necessary transformers and rotary converters for this purpose being installed in a separate sub-station. This station, which is used as a standby for the works and also to supply current to the electric furnace in the light steel foundry, contains 2—500 kw. converters and 2—250 kw. converters.

(*To be continued.*)

Electric Igniter for Oil Fuel Burners.—The White Patent Oil Burning Company, Limited, of Shadwell-street, South Shields, has just introduced a handy little apparatus intended to do away with the messy flame torch and oil pot commonly used to light up the burners of oil-fired installations. The appliance is 3 ft. 3 in. in length, and at one end is fitted with an element which can be raised to a red heat by electric current, connection for which is made by means of a length of flexible cable running from the rear end of the igniter to any convenient wall plug. A switch is provided on the igniter, and in use the appliance is pushed into the furnace through the sight-hole in the furnace door and the current switched on. In a few seconds the element becomes red hot, and if the burner valve be opened the oil will at once ignite. The instrument has the advantage of dispensing with a naked light in the boiler-room It is made for a voltage of from 100 to 120.

Concrete on British Railways.—At a meeting of the Institution of Structural Engineers, formerly the Concrete Institute, on the 16th ult., a paper by Mr. W. Marriott on "Concrete on British Railways" was read. This paper can hardly be considered exhaustive, for it dealt mainly with signal posts, short sections only being devoted to bridges, fence posts and sleepers. Mr. Marriott is a keen advocate of reinforced concrete and was early successful in the design of signal posts of this material, and later produced standardised units of 4 ft. each which could be built into poles at the erection site, thus saving considerably in transport costs. As regards concrete sleepers, Mr. Marriott considered that we had a long way to go yet before these could be said to be satisfactory. The latter half of Mr. Marriott's paper was concerned with the subject of cement. In this he discussed the advantages of adding trass to the cement to combine with the free lime in Portland cement. From this Mr. Marriott turned to the quality of the cement used by the Romans, which was perfectly hard to-day, almost 2,000 years after it was used. He also touched on the subject of Ciment Fondu with which we dealt recently in these columns.

4-H.P. MOTOR-CYCLE AT THE CYCLE AND MOTOR-CYCLE SHOW.

CONSTRUCTED BY MESSRS. DOUGLAS MOTORS, LIMITED, BRISTOL.

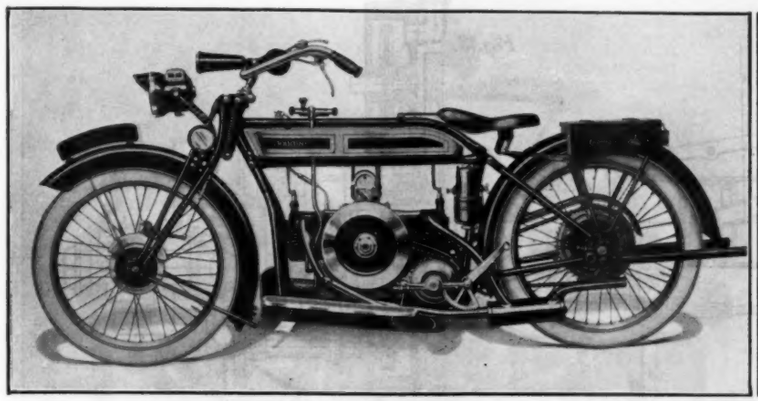


FIG. 8.

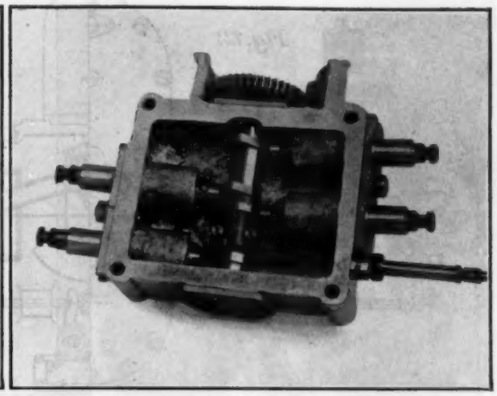


FIG. 9.

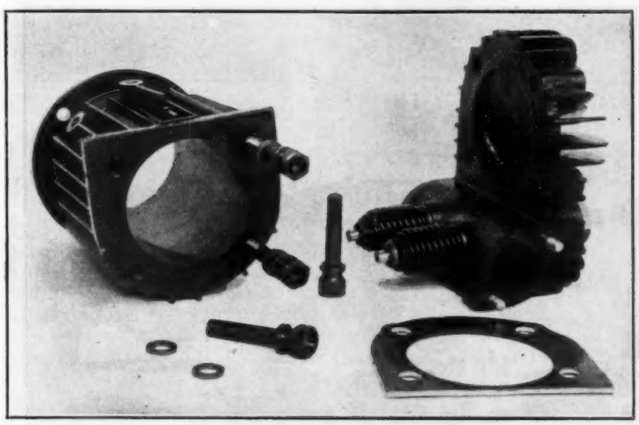


FIG. 10.

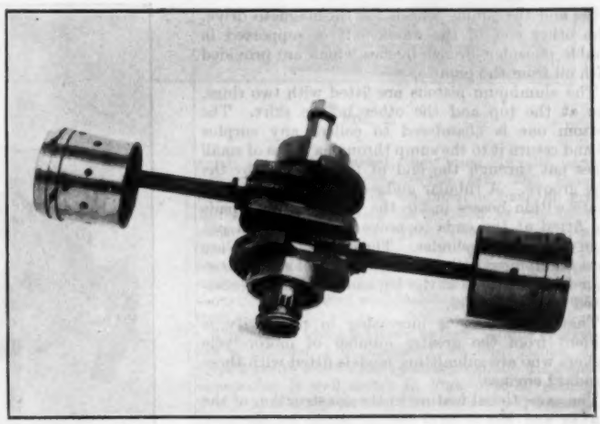


FIG. 11.

THE CYCLE AND MOTOR-CYCLE SHOW.

(*Continued from page* 684.)

A REPRESENTATIVE motor-cycle with an air-cooled four-stroke engine, that constructed by the Raleigh Cycle Company, of Lenton, near Nottingham, was described in our columns recently (see ENGINEERING, current volume, page 264). That machine is a good example of the best practice in the design of cycles for solo riding, and the detailed drawings then given of the engine, of 350 cub. cm. capacity, indicate an endeavour to keep down the weight and number of the parts as far as is consistent with reliable service.

The motor-cycles manufactured by Douglas Motors, Limited, of Bristol, may be taken as the outstanding examples of machines with horizontally-opposed twin cylinders where air cooling is used. The illustrations, Figs. 8, 9, 10 and 11, annexed, show the general design of the cycle and the relationship of the components and details of the engine.

The machine shown has an engine whose cylinders have a bore and stroke of 74·5 mm. and 68 mm., respectively, which gives a total capacity of 595 cub. cm. A solid camshaft (Fig. 11), gives motion to the inlet and exhaust valves of both cylinders through adjustable tappets. Simple cylinder castings (Fig. 10) are used, to which the heads are connected by bolts. The gas ports and valve seats are in an extension of the cylinder head. A view of the complete assembly of crankshaft, connecting rods and pistons (Fig. 11), gives an indication of the construction of the moving system. The cranks for the two pistons are directly opposite one another and are balanced by the large extensions to the opposite sides of the centre line. At the end of the crankshaft a small pinion is provided to give motion through the gear wheel on the camshaft to operate the valve.

A three-speed gear is fitted to this model, with wheels made of nickel steel with 5 per cent. of nickel. The gear ratios provided are 5·9, 9 and 13·8 to 1. The frame is built up of weldless steel tubing with the head lugs machined out of solid steel. Magneto ignition is used and the magneto is erected above the crank-case.

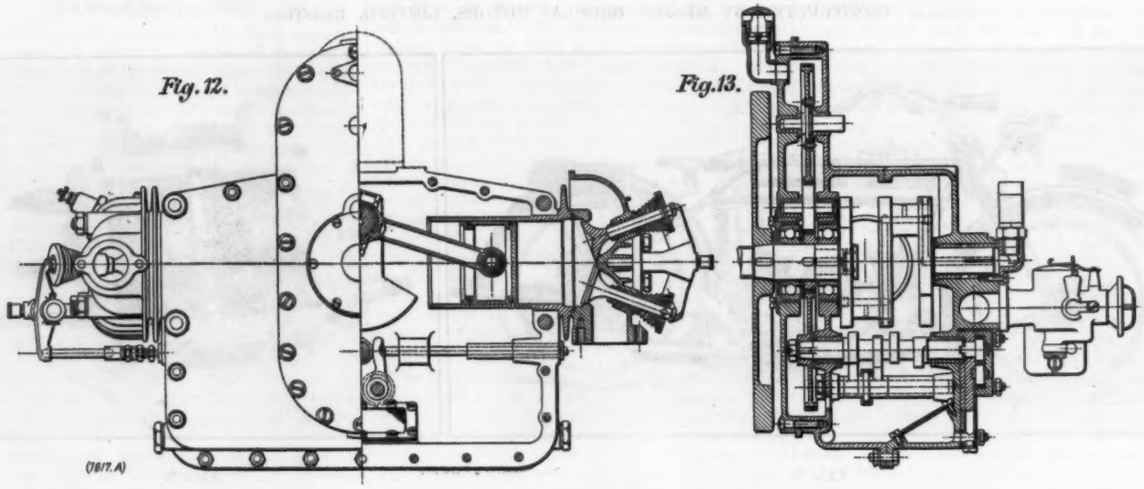
It is claimed that there is very little vibration with the opposed type of twin-cylinder engine, and that the machine is suitably built to meet the conditions of stress due to heavy duty is evident from the successful use of these machines in war service and in competitions. The first motor-cycle of the 500-cc. class to exceed a speed of 100 m.p.h. under official observation was of this make.

The replacement of the ordinary system of air-cooling by the process of splashing oil against the heated part of an engine and cooling it by contact with the crank-case wall, has been adopted in the Bradshaw engine, which is manufactured by Messrs. James Walmsley and Co., of Preston. Single cylinder and two-cylinder engines have been designed to make use of this principle, and the larger model is illustrated in Figs. 12, 13 and 14, on page 706.

The cylinders of this engine, which have a total capacity of 500 cub. cm., are enclosed within the crank-case. The level of oil within the case is kept at about 1½ in. from the bottom. A gear pump driven from the camshaft is used to draw the oil from the sump through a gauze filter and deliver it, under pressure, by an external pipe to the internally-drilled crankshaft. The oil release grooves in the crankshaft, used to throw the oil about, are shown in Fig. 13. After the oil has been heated by its contact with the working parts it falls back to the sump. The outside of the crank-case is used as a radiating surface to dissipate the heat imparted by the engine to the oil. A drain plug in the crank-case is provided to release all the oil if necessary. The cylinder heads are hemispherical in shape, carry the rocker gear for the valves, and are held in place by four bolts and nuts. Radiating gills are provided over the whole of the outside of the cylinder heads to keep down their temperature. The inlet and exhaust valves are set side by side on a diameter of the cylinder head and the plug is in a position between them but towards the side of the cylinder top. The shapes of the valves and the detachable valve guides are shown in Fig. 12, as well as the manner in which the valves are held against their seats by conical springs.

The mechanism for the operation of the valves, apart from the rockers and part of the push rods, is entirely inside the crank-case and receives ample lubrication. The cylinders are perfectly symmetrical and oil is sprayed upon them continuously from the crankshaft. A single solid forging is used for the crankshaft and balance weights, and is machined all over, case-hardened and ground to finish. On the flywheel side the crankshaft is supported on double journal ball bearings, the space between which is occupied by the camshaft gear

EXHIBITS AT THE CYCLE AND MOTOR-CYCLE SHOW.



drive and the timing wheels for the magneto drive. The other end of the crankshaft is supported in double phosphor-bronze bushes which are provided with oil from the pump.

The aluminium pistons are fitted with two rings, one at the top and the other in the skirt. The bottom one is chamfered to collect any surplus oil and return it to the sump through a series of small holes cut through the end of the piston into the ring groove. A tubular gudgeon pin is used which floats within bosses inside the piston. Brass pads are fitted at the ends to prevent the gudgeon pin from scoring the cylinder. The connecting rods are steel stampings, with bearings made of split phosphor-bronze bushes at the big ends, which are lubricated under pressure.

That oil cooling is increasing in popularity is evident from the greater number of motor-cycle makers who are submitting models fitted with these standard engines.

The exceptional feature in the construction of the Phelon and Moore motor-cycle, made by the firm of that name whose works are at Cleckheaton, is the position of the engine. It is mounted as a part of the frame and four rods pass right through the cylinder casting and the crank-case to take the stresses usually borne by the front tube frame member. The arrangement may be seen in the view of the 4½-h.p. model, Fig. 15, annexed.

Apart from the situation of the engine, which, of course, has the advantage of providing ample accommodation for a large single-cylinder unit without the necessity for increasing the height of the upper parts of the frame, the general structure follows orthodox lines. Circular channels are provided, as projections on each side of the crank-case, and these are set in line with similar openings in the cylinder. The four rods are passed through these holes and fixed at the ends to four lugs, two at the top and two at the bottom, which are bolted to the frame. The machine illustrated is fitted with a four-speed gear. There is no doubt that there is a demand for such a range of speeds by the motor-cycle public, whose present outlook is not only that the motor-cycle must climb the steepest hills in any tour, for which the low-gear ratio of 17½ to 1 in this machine is suited, but also that they must have a gear in which some position of setting will meet nearly all of the momentary conditions of gradient and road, and thus reduce the amount of crawling they would otherwise have to do. The top gear on the side-car machine has a ratio of 5·3 to 1. Four speeds have been fitted to the solo mount, with ratios running from 3½ to 1 up to 11 to 1. Control of the gear is effected by a hand lever on the tank and a rocking pedal. When the lever is set in one position the two top gears are operated by the pedal; and in the other position, the two lower gears. Mechanical lubrication delivered through a sight-feed on the tank, enclosed valve gear and a half-compression device for use in starting are other features in these machines. The engine has a cylinder of 3 1/16 in. bore and 3 11/16 in. stroke, dimensions which give a cylinder capacity of 555 cub. cm.

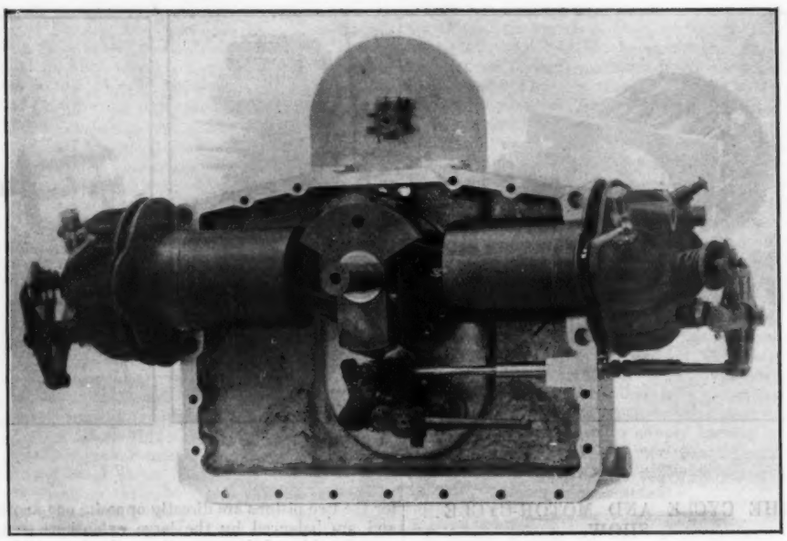


Fig. 14.

Figs. 12 to 14. Bradshaw Oil-Cooled Engine; Messrs. James Walmsley and Co., Ltd., Preston.

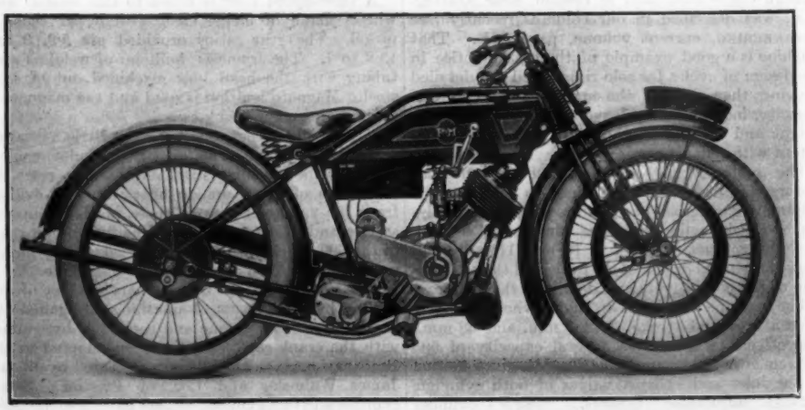


Fig. 15. P. and M. Motor-Cycle; Messrs. Phelon and Moore, Limited, London.

The production of a light runabout type of car at a price which will attract the motor-cycle user presents problems in design quite different from those of either the cycle or ordinary car. A small

3-B.H.P. HOPPER-TYPE PARAFFIN ENGINE.

CONSTRUCTED BY MESSRS. DRUMMOND BROTHERS, LIMITED, ENGINEERS, GUILDFORD.

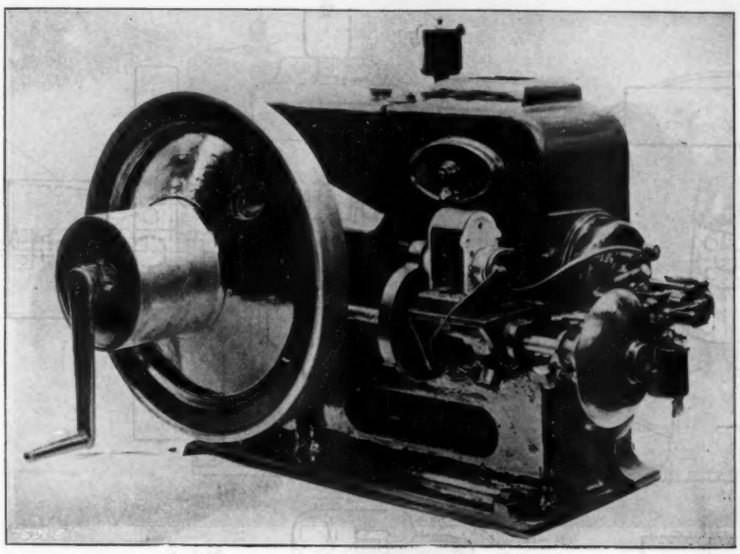


FIG. 1.

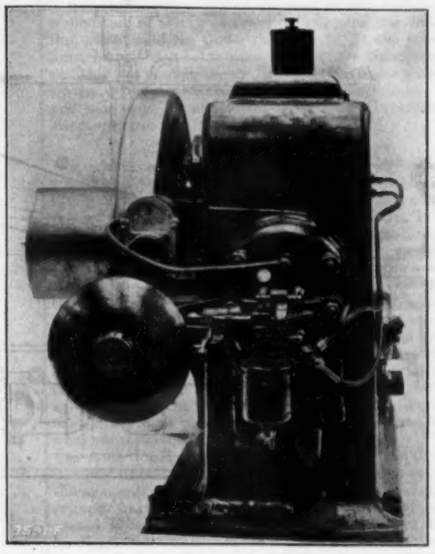


FIG. 2.

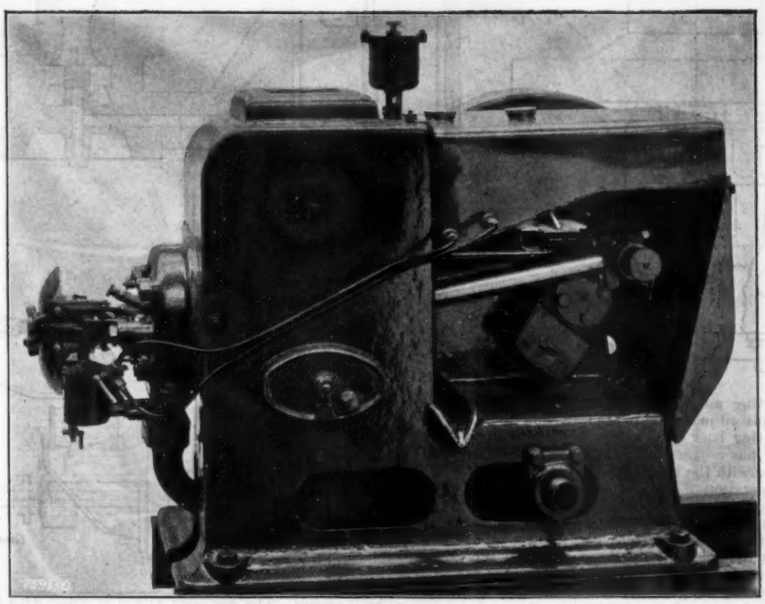


FIG. 3.

power unit must be used and the arrangements made for mounting it on the vehicle and obtaining the necessary drive must be not only simple and serviceable but also exceedingly light in weight. The design of an ordinary car might be modified by reducing the sections of all the parts of the structure and using a smaller engine. This method of approaching the problem is, however, not a satisfactory one, or likely to lead to the production of a successful type of machine. All the refinements necessary on an ordinary car are not needed in the cycle car and the best way of looking at the problem is to study it as a modification of a cycle and side car.

The irrational system of taxation of motor cars and cycle cars has led to the development of the three-wheeled vehicle, but, with more reasonable arrangements, there is little doubt that the three-wheeled cycle car would drop out of recognition. This phase of the motor tax problem has received very little consideration, but there is no doubt that an increased number of designs of four-wheeled cycle cars would be placed upon the market if they were considered for taxation purposes as modifications of the cycle, although on four wheels, rather than as ordinary motor cars.

In this field originality has a fair amount of scope, as arrangements that might prove quite ample for such a light vehicle would be quite out of the question altogether for the heavier motor car.

(To be continued.)

3-B.H.P. HOPPER-TYPE PARAFFIN ENGINE.

MESSRS. DRUMMOND BROTHERS, LIMITED, of Guildford, have added to their other well-known lines of manufacture by the introduction of a small oil engine, suitable either for fixing permanently in position or mounting on a truck. Judging by the very large number of different makes of engines of this class which are on the market, they must, in the aggregate, have a very considerable sale, and Messrs. Drummond's engine will, we imagine, have no great difficulty in establishing its position as one of the leading examples of its type. The appearance and finish of the engine is in every way worthy of the reputation of its makers, while we understand the price makes it a direct competitor with some of the really shocking examples of workmanship which are imported from abroad.

The engine, which is known as the "Willing Worker," has a cylinder 4 in. diameter by 6-in. stroke, and gives 3 b.h.p. when running at 600 r.p.m. Its general appearance is well shown in Figs. 1 to 3, annexed, from which it will be seen that while the arrangement is compact, the whole of the valve and other mechanism is open and easy of access, and well away from the flywheel, belt and crank. The crank is well guarded by the form of the engine frame, the fuel tank above it, and the front guard. The engine is especially suitable for work on farms or estates, and requires no skilled supervision. The valve gear is very simple, while the easy starting device and the patented magneto drive should add greatly to the convenience of the engine in unskilled hands. The details of the construction of the engine will be followed from Figs. 4 to 6 on page 708. The main casting comprises the engine bed, the cylinder and water hopper, the main bearing bracket, and the magneto bracket in one piece. This casting is furnished with bolting-down lugs, and forms the main frame, so that no sub-base is required. Hand holes are provided on each side of the water hopper, which surrounds the whole length of the cylinder.

The cylinder head is detachable and carries all valve gear, only one watertight joint being needed. The head is fully water-cooled, the valves being thus kept free from warping troubles. To the two large bosses to be seen on the head there is bolted a bridge piece, which carries the pins to which the valve springs are fixed. These springs work in tension and are well away from the hot exhaust. The bridge carries the easy starting gear, described later, and a bracket piece, on which the governor throttling lever is pivoted. A flange on the lower portion of the head carries the carburettor body, through which passes the hot exhaust on its way to the silencer. The float chamber is bolted to the body, and is supplied by the two pipes from the petrol and paraffin tanks through a two-way cock. The choke tube and jet are of the usual car type.

The combined crank and balance-weight piece is of cast-iron, and is force-fitted to the crankshaft, and held on further by four bolts passing into a turned flange on the shaft. The crankpin is forced into the crank, and held by a large retaining nut. The main bearings have white metal liners, while between them is a chamber in the bracket portion of the casting, in which run the spiral gears driving the camshaft; this chamber forms an oil bath for the gears. The camshaft runs in white metal bearings at the gear end, and in a cast-iron

3-B.H.P. HOPPER-TYPE PARAFFIN ENGINE.

CONSTRUCTED BY MESSRS. DRUMMOND BROTHERS, LIMITED, ENGINEERS, GUILDFORD.

Fig. 4.

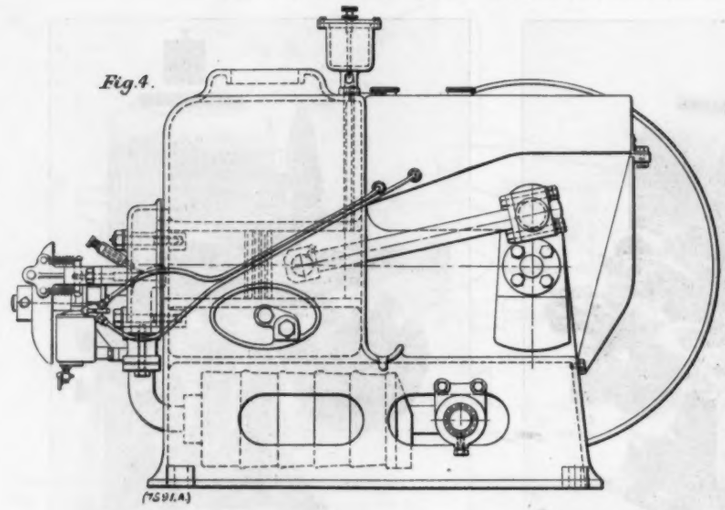


Fig. 5.

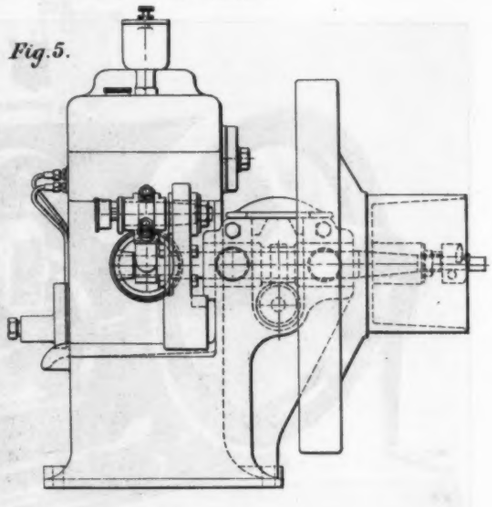


Fig. 6.

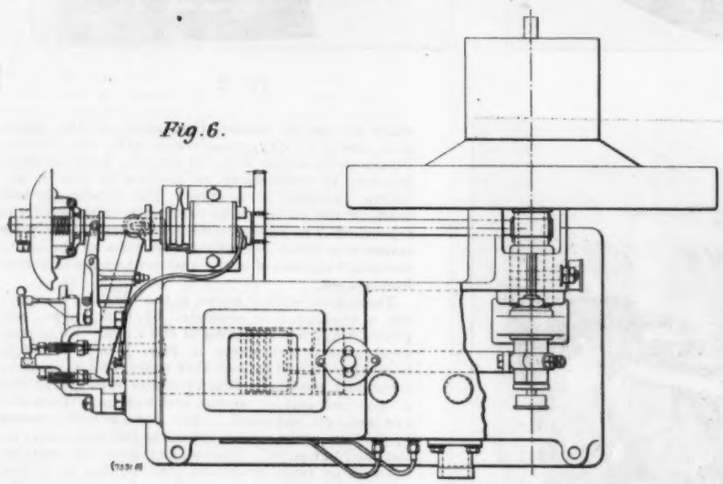


Fig. 7.

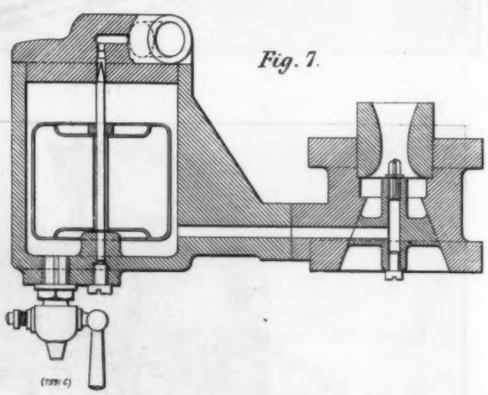


Fig. 8.

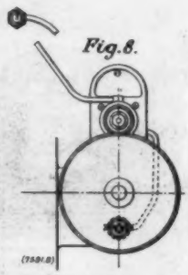
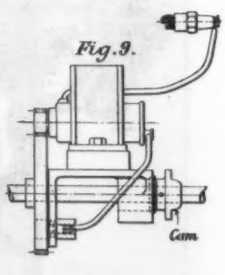


Fig. 9.



bearing in the magneto bracket. The camshaft carries the single cam and the governor at its outer end, and runs at half-engine speed. Hardened steel-thrust washers are placed between the cam and the bearing in the magneto bracket, thus relieving the bearings of end thrust.

The governor is of the two-ball centrifugal type, and is contained within the dome-shaped casting carried by the camshaft. Two pairs of lugs carry pivots on which the weights swing, actuating the sleeve on the camshaft by means of extensions which work in a groove in the sleeve. The sleeve slides along the camshaft against the compression of a spring, and actuates the governor by means of the lever referred to previously, which carries at its end a small hardened roller working in a second groove in the sleeve. The inner end of the governor lever is connected to the throttle by means of a link, the centrifugal motion of the balls thus being communicated direct to the throttle. The throttle is of the butterfly type, and is situated immediately above the choke tube in the induction passage. The range of the governor may be controlled by means of a load spring and adjusting screw. The inlet valve is automatic; both valve stems project out well from the cylinder head, and carry a small yoke piece, to the two ends of which are hooked the valve springs. The exhaust valve rocker lever is pivoted on a pin carried by one of the bosses on the cylinder head, and carries at one end the roller working on the cam surface, and at the other bears on the small flange turned on the stem of the exhaust valve by means of a forked end. The carburettor is illustrated in Fig. 7.

The easy-starting gear consists of a lever which has a ball pivot in the bridge piece on the cylinder head, and which bears on the inlet valve stem by means of a projecting pin when held in engagement by a catch lever placed just underneath it. The catch lever has a projecting boss on one side, and the domed governor casing has a cam on its outer edge, which comes into contact with the boss if the easy-starting gear is in use. The operation of the device is as follows: The easy-starting lever is depressed and held by the catch lever. The engine now has no compression as the inlet valve is open. The flywheel may be given a good easy swing, and at the end of the first revolution of the camshaft the cam on the governor casing strikes the catch lever and throws the gear out of action. The flywheel has sufficient momentum to complete the cycle of firing operations.

The magneto is of the standard motor-car type, and needs no further description itself. The drive is by spur gears from the camshaft, the arrangement of the drive being the subject of a patent. The armature is geared to run at five times camshaft speed, thus ensuring that the spark is a good one even at the first slow swing of the crankshaft. The spark is only allowed to occur at the correct moment for firing by means of a special contactor arrangement. The earth from the magneto is made to pass through the driving gear, and this gear has a hole drilled through its web; bearing against the web of the gear is a spring plunger with a semi-spherical end, and this is insulated from the bracket which carries it. When the hole in the gear web passes the spring plunger, a break occurs in the circuit, and a spark is made at the plug points. At all other times there is complete electrical circuit, and therefore no sparks at the plug points. The arrangement is detailed in Figs. 8 and 9.

The supply of air for combustion is regulated by a shutter sliding over an aperture in the base of the carburettor body, the shutter being kept in any position by a spring. The cast-iron piston is fitted with four rings, the gudgeon pin being placed in the centre of wall area. The pin is a sliding fit in the piston bosses, and is locked in the small end of the connecting rod by a square-headed set screw. The big end bearings are of cast-iron, the cap being held by two bolts and lock-nuts. Lubrication of the cylinder is by means of a sight-feed lubricator, with no glass; the oil pipe passes through the water hopper, and the oil is therefore kept fluid in the coldest of weather. Stauffer type lubricators are fitted to the crankpin end, the main crankshaft bearings, and the camshaft bearing. The engine starts up on petrol, and in warm weather may be switched over directly to paraffin. In cold weather the engine must be run for about five minutes before changing over. There are two compartments in the fuel tank, a small one for petrol, and the large main tank for paraffin. The change-over is only a matter of turning the tap of the two-way cock.

An all-steel trolley has been designed for use in connection with this engine in order that it may be converted into a portable unit. It is of the same type as the trolley shown in Fig. 10 on page 709, which is, however, made longer in order to accommodate a

3-B.H.P. PARAFFIN PUMPING SET AND SAW.

CONSTRUCTED BY MESSRS. DRUMMOND BROTHERS, LIMITED, ENGINEERS, GUILDFORD.

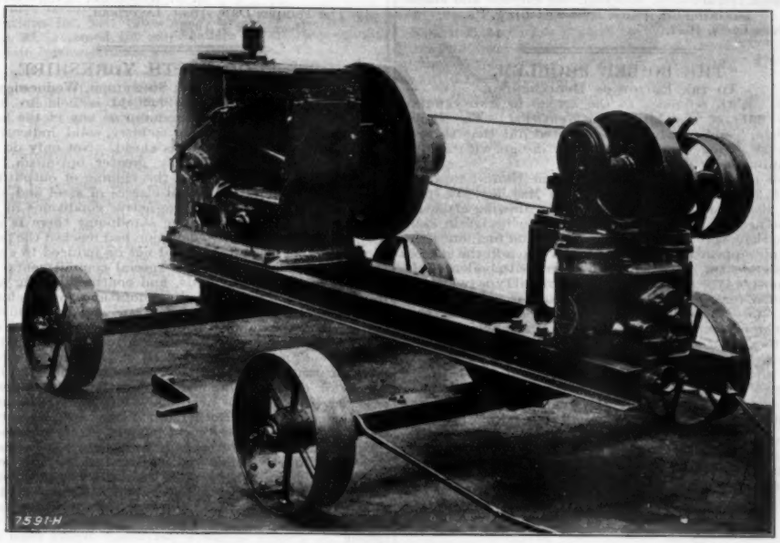


FIG. 10.

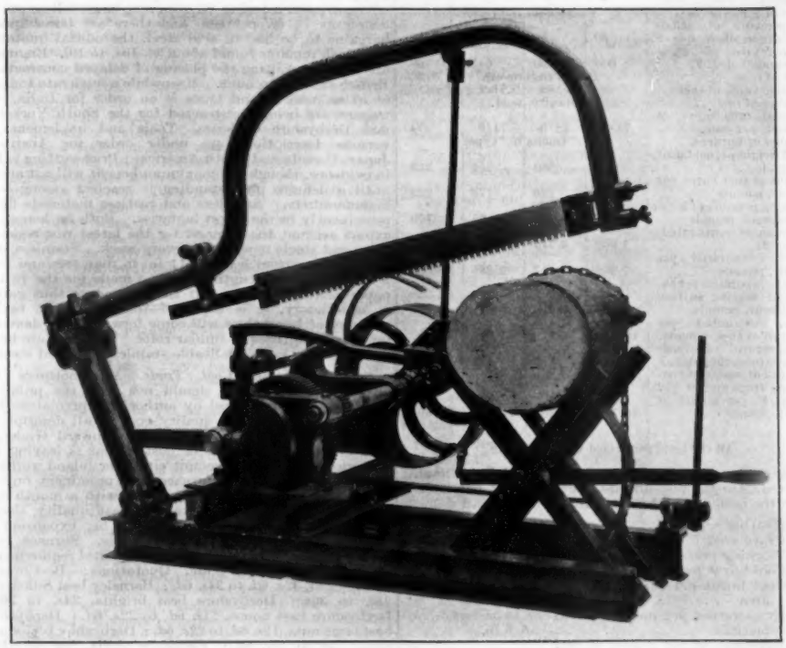


FIG. 11.

pump or saw, driven by the engine, so that the whole forms a self-contained pumping or sawing unit which should be of great convenience for estate or farm work. The pump is shown in position on the trolley in Fig. 10, while the saw is shown separately in Fig. 11. The pump, when driven at 60 r.p.m., will deliver 1,000 gallons of water a minute against a head of 100 ft. It has two cylinders of 3-in. bore and 4-in. stroke, and is fitted with rubber ball valves so that it may deal successfully with muddy water. The details of the saw unit will be clearly understood from Fig. 11. A saw of this class is probably much more suitable for dealing with the rough and uneven timber likely to be met with on an estate than is a circular saw. The power required is also much less. As will be clear, the ingenious chain grip will hold timber of any shape securely on the sawing horse. The material is simply placed in position below the chain, and the hand-lever is lifted until a grip has been obtained. The handle is then held in position by the fixed rack in front of the horse.

INDUSTRIAL NOTES.

A DEPUTATION from the Miners' Federation was received last Saturday by the Prime Minister. Mr. Herbert Smith, president of the Federation, put the case for the miners, and stated that the coalfields to-day were over 40 points worse off than in 1914 from the cost of living point of view; in addition, a large number of miners were getting full unemployment benefit, and a number partly employed were receiving relief from guardians. Mr. F. Hodges pointed out that the present average wage of all the workers engaged in the industry, on the September ascertainment, was 9*s.* per shift, the wage in 1914 having been 6*s.* 5½*d.* per shift. The increase in the cost of living, 80 per cent., on 6*s.* 5½*d.* should give a wage of 11*s.* 7½*d.*, as against the 9*s.* average referred to. In the discussion, the railway rates, reparation coal and other matters were reviewed by both sides. In the course of his reply the Prime Minister said he thought Mr. Hodges was too pessimistic in regard to the chance of an improvement in the market; he felt quite sure that if the industrial improvement in iron and steel, of which he was told there were signs, continued, it would have a very material effect on the price of coal and greatly increase the demand. It was easy to say that it was the business of Government to put right such a condition of things as that now affecting the miners. But what could the Government do? At the present time, benefit was being paid to 1,400,000 unemployed, and this was costing the State 100,000,000*l.* per annum. He fully recognised the hardships of the miners, but saw no way of alleviating them by Government intervention.

Speaking at the twenty-second ordinary general meeting of the shareholders of the Horden Collieries, Limited, last week, Sir Hugh Bell, chairman, referred to the wages settlement in collieries of July, 1921,* adding that after an experience of twelve months with the settlement, both sides were dissatisfied with the results. The settlement of 1921 had been got to work during the past twelve months, and it was to be hoped that by dint of reasonable mutual concessions matters would succeed equally well in the present year. Another point of deep moment to the coal trade was the statutory reduction of hours from 8 to 7 which came into force in July, 1919. At Horden all possible contrivances to save labour had been adopted, but in spite of these, the loss in working hours had involved the employment of about 15 per cent. more men than were required before the passing of the Act. There was some doubt as to whether, in existing conditions, it would be possible to mine coal in this country to meet the competition of the world. The question was one of primary importance to the iron trade, since fuel represented about one-third of the cost of a ton of steel. Sir Hugh Bell was convinced it was a fundamental error to regard the coal miner as a being apart, to be dealt with in ways which were not applicable to all other labour. Labour must be looked at as a whole; the coal-miner's wage, if left to itself, would be governed by the general laws which govern wages.

Mr. Finlay Gibson, secretary of the South Wales Coalowners' Association, has issued a statement saying that the certificate of the joint accountants on the South Wales coal industry for October shows that, after allowing for the cost of standard wages and the owners' standard profits, the surplus available is 194,388*l.* This is not sufficient to meet for the month of December the minimum wage of 28 per cent. on the base rates, and in order to pay it the owners will have to sacrifice 201,312*l.* of the standard profits. Since November of last year, he adds, the South Wales coal-owners have forfeited nearly 3,000,000*l.* of standard profits in order to pay the minimum wage.

On the 1st inst. there came into force a series of reductions in the rates for the transport by rail of the raw materials used in the manufacture of iron and steel, and of manufactured iron and steel articles. The reductions vary with the class of material as, coal and other fuel, ironstone, &c., manufactured products; and they are expected to aid the industrial improvement in iron and steel of which there was now some evidence.

With further reference to our notes on pages 141 and 459 *ante*, in the matter of putting into effect the second 5 per cent. reduction on the April, 1921, rates, the National Federated Electrical Association state they have heard from Mr. Rowan, secretary of the Electrical Trades Union, that the result of the ballot vote of his members, is in favour of the acceptance of the recommendation. The reduction is to take effect on the first pay day following Sunday, January 7, 1923, for the period covered by that pay day, when the rates will be: Grade A, 1*s.* 8½*d.*; Grade B, 1*s.* 6½*d.*; Grade C, 1*s.* 5*d.*; Grade D, 1*s.* 3½*d.* It will be remembered that the agreement was reached at York on July 27, and was amended at a conference held on November 2 last.

The Guaranty Trust Company, New York, states that the American pig-iron production in October was the largest for any month since December, 1920. It exceeded by over 200,000 tons the production in July, the previous high mark for any month this year. The daily rate of production increased by 28 per cent. over September. The daily capacity of 218 furnaces in blast on November 1, was 14 per cent. greater than that of 189 furnaces in blast on October 1. Steel ingot production showed 21 per cent. increase. During October, with the mills operating at between 75 per cent. and 80 per cent. capacity, steel was produced at the rate of 40,000,000 tons per annum, which is 9 per cent. increase over the previous high mark for the year, in June. Based on the amount of coal loaded

* See ENGINEERING, vol. cxii, pages 13 and 640.

at the mines, the estimated coal output for the week ended November 18 was 13,200,000 tons, of which 11,100,000 tons was bituminous and 2,100,000 tons anthracite. The aggregate bituminous coal output thus far this year was only 6·4 per cent. less than for the corresponding months of 1921; the anthracite output showed a loss of a little more than 50 per cent.

"THE RELATION BETWEEN MAGNETIC HYSTERESIS LOSS AND COERCIVE FORCE."

To the Editor of Engineering.

Sir,—Referring to the article by N. L. Anderson and E. M. C. Lance, entitled "The Relation between Magnetic Hysteresis Loss and Coercive Force," appearing in Engineering for September 22, 1922, on page 351, we happen to have some data bearing on this subject which should be of interest. During the past few years we have had occasion to obtain hysteresis loops ballistically on many hundred samples of various kinds of ferromagnetic materials. Some of these loops were for a maximum induction of 15 kilogausses, but most of them were for 10 kilogausses. In order to save the time required to planimeter these loops we attempted several years ago to derive a quick method of estimating loop areas with a reasonable degree of accuracy. The method, which we have verified only for hysteresis loops having a maximum induction of 10 kilogausses, was described in *The Electrical World*.* We had previously considered using the relation $W_h = \frac{B_m \times H_c}{\pi}$ as a means of approximating the loss, but found this to be too inaccurate for our purpose. It soon occurred to us, however, that by applying a correction factor which was a function of the width of the loop at some other place than zero induction, we could obtain a fairly accurate estimate of the loop area. By many trials we found the best position at which to determine this correction factor to be in the neighbourhood of 8 kilogausses, for a 10-kilogauss loop. The average constant for $B_m = 10$ kilogausses, as determined by Anderson and Lance, is 1·01. Our formula for K at $B_m = 10$ kilogausses is,

$$K = \frac{2\,H_8' - H_8''}{2\,H_c + (H_8' - H_8'')} \text{ where}$$

$H_8' - H_8''$ is the width of the loop at B = 8 kg.

H_8' is the maximum value of H corresponding to B = 8 kg.; and H_8'' is the minimum value of H corresponding to B = 8 kg.

H_8' and H_8'' must be subtracted algebraically.

We have then:

$$W_h = \frac{K \times H_c \times 10^4}{\pi}$$

for 10 kilogauss loops.

The following table shows the results on 14 samples chosen at random. These are all approximately 4 per cent. silicon steel samples in which magnetic viscosity effects are negligible. B × 4 H_c and A are in arbitrary units.

Sample.	$B_m \times 4\,H_c$.	A.	Per Cent. Error.	K.	$B_m \times 4\,H_c \times K$.	Per Cent. Error.
A	38·4	37·4	+ 2·6	0·99	38·0	+1·6
B	27·7	26·0	+ 6·5	0·96	26·5	+1·9
C	4·80	4·74	+ 1·3	1·00	4·80	+1·3
D	15·0	13·2	+13·6	0·93	13·8	+4·5
E	33·6	34·2	− 1·8	1·06	35·5	+3·8
F	32·4	33·5	− 3·3	1·06	34·3	+2·4
G	10·9	9·5	+14·7	0·915	9·95	+4·7
H	25·0	26·0	− 3·8	1·06	26·4	+1·6
I	16·0	15·1	+ 6·0	0·925	14·8	−1·9
J	11·2	10·6	+ 5·6	0·985	11·0	+3·8
K	23·8	22·9	+ 4·0	1·01	24·0	+4·8
L	29·0	31·0	− 6·4	1·05	30·5	−1·6
M	15·5	13·6	+14·0	0·905	14·0	+3·0
N	12·0	10·2	+17·6	0·86	10·3	+1·0

Without Factor K.

	Per Cent.
Mean error—	
Arithmetical ... ... =	7·24
Algebraic ... ... = +	5·04
Maximum + error ... ... = +	17·6
Maximum − error ... ... = −	6·4

With Factor K.

	Per Cent.
Mean error—	
Arithmetical ... ... =	2·7
Algebraic ... ... = +	2·2
Maximum + error... ... ... = +	4·8
Maximum − error... ... ... = −	1·9

These results are quite typical. It is evident that without our correction factor the estimate of losses from B_m and H_c only may be subject to considerable error. With the correction factor the errors, both maximum and average, are reduced to about one-third. The error obtained by using the product of B_m and 4 H_c without a suitable correction factor for each loop is stated by the Bureau of Standards to be less than 15 per cent.† It is not often that the error exceeds this figure, but occasionally we have found instances where the correction factor was 0·8 or less.

The variation of K with maximum induction, as given by Anderson and Lance, is very interesting and should be a useful function where approximate results are required. The determination of the variation of K with maximum induction for samples where the ratio of $B_m \times 4\,H_c$ to the true area of the loop departs considerably from the value 1·01 would be instructive.

Yours very truly,

Thos. Spooner.

Research Department, Westinghouse Electric and Manufacturing Company, East Pittsburg, Pa.
November 8, 1922.

* "Rapid Testing of Magnetic Materials," *Electrical World*, July 5, 1919.

† "Magnetic Testing," Bureau of Standards Circular, No. 17, page 37.

"THE BOILER PROBLEM."

To the Editor of Engineering.

Sir,—With reference to the article in Engineering (page 681) of the 1st instant, entitled "The Boiler Problem," and in which it is pointed out that there is need for giving attention to boiler design with a view to obtaining better results.

You published a letter of mine in Engineering of March 24, 1922 (page 370), also on May 5, 1922 (page 554), also on June 3, 1922 (page 686), drawing attention to the need of giving attention to boiler design in cases where they were intended for the use of oil fuel, but there does not appear to be much interest taken in the subject of boiler design, especially with reference to boilers of the locomotive type and boilers of the vertical type (which are intended for the use of oil fuel), and it will probably take many more years to convince boilermakers that much improvement can be achieved, and which would lead to a great saving of fuel, coupled with an increased efficiency of the boiler.

As showing what can be effected, I enclose herewith figures of a test with a Cochran vertical boiler which had been arranged specially for the use of oil fuel according to the writer's methods:—

Kermode's Patent Steam Jet Oil Fuel System, as Applied to a Cochran Vertical Multitubular Boiler, 5 ft. 6 in. diameter by 14 ft. high, by 300 sq. ft. Heating Surface, at the Barton Depot of the British Petroleum Company, Limited.

Evaporation Trials.

	(1)	(2)	(3)	(4)
Date of trial	18.10.22	19.10.22	19.10.22	19.10.22
Duration of trial, hours	1	3	2	1
State of atmosphere ..	F	air easterly breeze		
Temperature of atmosphere in shade, deg. F.	53	50	50	50
Temperature of gases (average), deg. F. ..	600	550	645	700
Kind of fuel	D	iesel engine oil.		
Calorific value of fuel ..		19,188 B.Th.U.		
Pressure of fuel		Gravity feed.		
Thermal efficiency of boiler, per cent. ..	74·9	62·9	71·9	74
Number of burners ..	One	"Orchan" type.		
Total weight of fuel burnt, pounds	156	380	351	223
Weight of fuel burnt per hour, pounds ..	156	126	175	223
Working pressure of boiler (average), pounds ..	100	107	95	100
Total water evaporated, pounds	1,908	4,340	4,570	3,000
Water evaporated per hour, pounds ..	1,908	1,447	2,285	3,000
Water evaporated per sq. ft. of heating surface per hour, pounds ..	6·33	4·8	7·6	10
Water evaporated per pound of fuel, pounds..	12·23	11·47	13·05	13·45
Temperature of feed-water (average), deg. F.	52	176	170	170
Equivalent water evaporated from and at 212 deg. F. per pound of fuel, pounds	14·73	12·36	14·13	14·56

All the tests performed without smoke.

The boilermakers' (Messrs. Cochran and Co. (Annan), Limited, Annan) test affords the following particulars when the boiler is fired with coal:—

Heating surface	300 sq. ft.
Grate area	16·75 sq. ft.
Working pressure	100 lb. per sq. in.
Coal burnt per hour	383 lb.
Coal burnt per sq. ft. of grate area	22·7 lb.
Evaporation per pound of coal (actual)	5·6 lb.
Evaporation per pound of coal from and at 212 deg. F. ...	6·72 lb. (about)
Evaporation per hour (actual). .	2,160 lb.
Evaporation per hour from and at 212 deg. F.	2,592 lb.

Comparing the foregoing figures of evaporation with those obtained with oil fuel in the case of a boiler which has been suitably modified to meet the peculiar needs of oil fuel, it will be seen at a glance that in this particular case, and even when the boiler is carrying an overload of 25 per cent., that the evaporation per pound of oil burnt exceeds the listed evaporation obtainable with coal in the proportion of 2·16 to 1, whilst the efficiency is high even at the overload performance.

The result was obtained when using the Kermode steam jet oil burner, and I would naturally expect a further gain of 6 per cent. if my pressure jet oil-burning system had been used. The figures should be somewhat of a warranty that boilermakers can (if they will) go a long way to improve matters, if they can be persuaded to take advice and note some of the points cited in my earlier letters. We have recently obtained an overload of over 40 per cent. on a Cochran boiler on the motor liner Adda without smoke, and this arises by adopting proper methods in boiler design, and which I have been advocating to small purpose for the past 15 years.

I am contributing a paper which is to be read at the International Navigation Congress next year, where the various points *re* boiler design will be raised, so that the matter can be freely ventilated in the hope that good will result.

Yours faithfully,

J. J. Kermode, M.I.Mech.E.

35, The Temple, Dale-street, Liverpool,
December 4, 1922.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Iron and Steel.—Though Sheffield is held to have suffered as much during the slump as any of the large manufacturing centres in the country, solid indications are emerging of brighter times ahead. Not only do the leading manufacturers display greater optimism, but the condition of order books, the volume of output and the wealth of inquiries for all classes of steel and steel products point clearly to more active conditions in the early future. From the price standpoint there is also a welcome change. Until deflation had reached the point of exhaustion, consumers could not be induced to enter the market (except to cover special commitments) for more than immediate needs, and contract buying as a result was largely suspended. Quotations for all classes of manufactured goods and for raw and semi-finished materials now exhibit a firmer tendency, with here and there a definite rise. It is generally believed that as soon as consumers are convinced of the upward movement of values, they will be anxious to secure the best terms for the large number of constructional schemes that are known to be pending. Output of basic steel in the Sheffield and Rotherham districts shows a consistent rise. One of the most modern plants possessing a complement of 14 furnaces is working at 50 per cent. pressure; more crucible and electric furnaces are being put into commission to deal with the larger demand from home and export buyers; and after a period of unexampled difficulty, largely arising from tariff increases in consuming countries abroad, high grade steels are taking on a more active appearance. Apart from the increased demand for basic steels, the increased cost of pig-iron and the shortage of steel scrap have compelled a partial revision of selling prices. Basic steel has advanced 10*s.* a ton to 8*l.* 15*s.*, soft basic billets are 5*s.* dearer at 7*l.* 5*s.* per ton, and there are fewer special bargains to be had in acid steel, the official quotation for which remains round about 9*l.* 10*s.* to 10*l.* Engineers are eagerly awaiting the placing of delayed contracts on British railway account. Meanwhile a moderate tonnage of axles, wheels, and tyres is on order for India, and wagons are being constructed for the South Yorkshire and Derbyshire collieries. Tools and implements of various descriptions are under order for Australia, Japan, Canada and South America. Price-cutting is less in evidence, though the maximum benefit will not accrue until a definite understanding is reached among local manufacturers. Stainless and rustless materials figure prominently in the latest inquiries. Both on home and export account the demand for the latest rust-resisting irons and steels is widening every week. Stainless steel rolls varying from 9 in. to 11 in. in diameter and from 8 ft. to 12 ft. in length are being made for the British paper-making industry. If the experience thus gained is satisfactory, it is expected that the great textile industry of Lancashire will come forward with demands for large quantities of similar rolls. New uses are being found for the latest malleable stainless iron and steel.

South Yorkshire Coal Trade.—Manufacturers are anxious that collieries should not crab the promised revival in iron and steel by authorising premature fuel advances, but for best quality coal of all descriptions the tone is distinctly firm, with an upward tendency. The whole of the output of best steams is leaving the collieries on contract account either for inland works or export. Railways and furnaces are prominent buyers. Nuts are 1*s.* a ton dearer compared with a month ago, and there is a ready market for best quality slacks. House coal merchants anticipate a big expansion in business between now and Christmas. Furnace coke is still in good demand, though Continental requirements are on a slightly lower scale. Quotations:—Best branch handpicked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 24*s.* to 26*s.*; Derbyshire best house, 21*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best large nuts, 19*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.* 6*d.*; Yorkshire hards, 20*s.* to 21*s.*; Derbyshire hards, 19*s.* to 20*s.* 6*d.*; rough slacks, 8*s.* 6*d.* to 10*s.* 6*d.*; nutty slacks, 7*s.* 6*d.* to 8*s.* 6*d.*; smalls, 3*s.* to 5*s.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is rather quiet, and values are inclined to ease. Continental competition is again being experienced, French iron having been sold to Scotland, through merchants here at appreciably below what Cleveland iron can be delivered at. Whilst producers are loath to make price concessions, customers report that they can purchase at below the following recognised market quotations:—No. 1 and siliceous iron, 96*s.* 6*d.* to 97*s.*; No. 3 G.M.B., 91*s.* 6*d.* to 92*s.*; No. 4 foundry, 87*s.* 6*d.*; No. 4 forge, 82*s.* 6*d.*; and mottled and white, 81*s.*, all f.o.t. or f.o.b.

Hematite.—The situation as regards East Coast hematite may be described as satisfactory and encouraging. Good inquiries continue to circulate, and the enlarged output is reported well taken up. Stocks at makers' yards are small, and several makers have not only disposed of what iron they had on hand, but have

sold their production a few weeks ahead. A few contracts for delivery over periods next year have been entered into. Mixed Nos. are 93*s.* 6*d.*, and No. 1 is 94*s.* 6*d.*

Foreign Ore.—There is still very little doing in foreign ore. Continued low prices fail to attract customers, and sales recorded are for only a few thousand tons. Quotations for best rubio vary considerably. As low as 21*s.* 9*d.* is named, but some sellers declare they cannot entertain business under 23*s.* c.i.f. Tees.

Blast-Furnace Coke.—Durham blast-furnace coke is in larger request, but local consumers are very disinclined to pay more than 29*s.* for medium qualities delivered, and transactions have occurred at round about that figure.

Manufactured Iron and Steel.—Much more interest is being taken in the finished iron and steel market. The placing of several more shipbuilding orders has had a stimulating influence on the situation, and prospects generally are much brighter. Demand for railway material and constructional steel, as well as for shipbuilding requisites, shows rather marked expansion. Common iron bars are 10*l.* 10*s.*; iron rivets, 11*l.*; packing, 8*l.*; steel billets, 8*l.* to 8*l.* 15*s.*, according to quality; steel joists, 9*l.* 10*s.*; steel boiler plates, 12*l.* 10*s.*; steel ship, bridge and tank plates, 9*l.* to 9*l.* 5*s.*; steel angles, 8*l.* 15*s.*; heavy steel rails, 8*l.* to 9*l.*; fish plates, 13*l.* to 14*l.*; black sheets, 11*l.* 10*s.*; and galvanised corrugated sheets, 17*l.* 10*s.*

Shipments of Iron and Steel.—November returns show the total shipments of iron and steel from Middlesbrough for that month, including 6,335 tons of pig-iron loaded at Skinningrove, to have been 81,587 tons, composed of 45,655 tons of pig-iron, 1,843 tons of manufactured iron, and 34,089 tons of steel. Of the pig-iron shipped from Middlesbrough 29,451 tons went abroad, and 9,869 tons coastwise; of the manufactured iron cleared, 1,585 tons went abroad, and 258 tons coastwise; and of the steel despatched 27,160 tons went abroad, and 6,929 tons coastwise. The chief receivers of pig-iron were the United States of America, 15,600 tons; Belgium, 6,009 tons; Wales, 5,725 tons; Scotland, 3,639 tons; France, 2,950 tons; and Sweden and Germany each well over 1,000 tons. The largest customers for manufactured iron were Mauritius, 610 tons; and India, 598 tons. Principal importers of steel were India, 9,575 tons; New South Wales, 3,876 tons; Japan, 2,008 tons; West Australia, 1,857 tons; and the Straits Settlements and Victoria, each over 1,000 tons.

Imports of Iron and Steel to the Tees.—Statistics issued this week give imports of iron and steel to the Tees from Holland, Belgium, France, Sweden, Norway and Germany, for the months of October-November, with comparisons for the same time last year, and for the corresponding pre-war period of 1913. Imports of pig-iron in the past two months were 350 tons, against 37,877 tons a year ago, and 268 tons in 1913. Billets, blooms, slabs and crude sheet bars unloaded here in October and November reached 10,488 tons, against 11,705 tons a year ago, and 10,986 tons in 1913. Plates, bars, angles, rails, sheets and joists arriving from abroad during the past two months totalled 1,549 tons, against 1,017 tons a year ago, and 3,601 tons in 1913.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—There has been little development in the Scottish steel trade over the week, and conditions show practically no change. The demand for ship plates has not yet expanded, and it will be a little time before specifications of any importance are given out. For structural sections the demand is again smaller, but there are prospects of an increase in business in the near future because of contracts fixed up recently. In the black steel sheet trade there is a fair amount of work doing, but it is largely confined to the thinner gauges and is mostly on export account. Galvanised sheets are moderately active, but, as in other branches of trade, makers are prepared to cope with a much larger demand. The general export trade continues poor. Prices to-day are without change and are as follow:—Boiler plates, 12*l.* per ton; ship plates, 9*l.* per ton; sections, 8*l.* 15*s.* per ton; and sheets, 10*l.* 10*s.* per ton; all delivered Glasgow stations. Galvanised sheets, 24 gauge, are quoted at 17*l.* 10*s.* per ton, f.o.b. Glasgow.

Malleable Iron Trade.—No improvement falls to be recorded in the West of Scotland malleable iron trade, as the demand is of very small proportions at the present time. The outlook is more encouraging as there is the likelihood of wagon builders being in the market for quantities of bar iron before very long.

Scottish Pig-Iron Trade.—The conditions in the Scottish pig-iron trade are not so satisfactory as they were and the falling-off in the American demand has not been counterbalanced by any improvement in home buying. Makers are now faced with the necessity of stocking foundry sorts or of blowing out some of their furnaces meantime. There is the possibility, however, that with the turn of the year the demand may be better. Hematite continues very quiet and with little sign of much improvement yet awhile. Prices are all the turn easier, but are without quotable change at 5*l.* 7*s.* 6*d.* per ton, for hematite delivered at the steel works, and No. 1 foundry iron at 5*l.* per ton, and No. 3 at 4*l.* 15*s.* per ton, both on trucks at makers' works.

Scottish Pig-Iron Shipments.—For the week-ending Saturday, December 2, the amount of Scottish pig-iron shipped from Glasgow Harbour was 2,413 tons. Of that quantity 2,342 tons went foreign and 71 tons coastwise. For the corresponding week last year the totals were 507 tons 10 cwt. foreign and 8 tons coastwise.

NOTICES OF MEETINGS.

THE INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Friday, December 8, at 7.30 p.m., in the Mappin Hall of the University, St. George's-square. Paper on "Cobalt," by Mr. W. R. Barclay, O.B.E.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, December 8, at 7.30 p.m. "Note on the Presentation of Ship Model Experiment Data," by Mr. E. V. Telfer, M.Sc., Assoc. Member.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, December 9, at 2 p.m., in the Lecture Theatre of the Institute, Newcastle-on-Tyne. Papers to be read and discussed:—"Aerial Wire Ropeways," by Mr. R. S. Tate, B.Sc.; "The Elimination of Power Losses and other Sources of Waste in Mines by the use of Ball and Roller Bearings," by Messrs. K. C. Appleyard and A. W. Macaulay. A safety brake for pit cages will be exhibited, described and demonstrated by Mr. Geoffrey L. Barton.

THE MINING INSTITUTE OF SCOTLAND.—Saturday, December 9, at 3 p.m., in the Royal Technical College, George-street, Glasgow. Papers to be read and discussed:—"An Inquiry into the Resistance to Traction of Mine Tubs," by Mr. John Wilson; "Testing of Centrifugal Ventilators, with Special Reference to Initial Water Gauge," by Mr. Henry C. Harris, B.Sc.; "The Working of Two Seams in Close Proximity," by Mr. R. A. Macdonald, B.Sc.

THE BRADFORD ENGINEERING SOCIETY.—Monday, December 11, at 7.30 p.m., in the Hall of the Bradford Technical College. Lecture by Mr. L. C. Perkin on "Spinning Tops and Gyroscopic Motion."

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—Tuesday, December 12, at 7.30 p.m., at 207, Bath-street, Glasgow. Paper, "The Possibilities of Transmission by Underground Cables at 100,000 to 150,000 Volts," by Mr. A. M. Taylor.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, December 12, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, London, when a discussion on "Recent Developments and Modern Requirements in Street-Lighting" will be opened by Mr. Haydn T. Harrison.

THE INSTITUTE OF INDUSTRIAL ADMINISTRATION.—Tuesday, December 12, at 8 p.m., at the Great Hall, London School of Economics, Houghton-street, Aldwych. A Lecture on "Standardisation of Repairs in Relation to Industrial Economy" will be delivered by Mr. Richard Twelvetrees, A.M.I.Mech.E., followed by discussion. Chairman, Mr. H. M. A. Tuckwell, M.I.Mech.E.

THE JUNIOR INSTITUTION OF ENGINEERS: NORTH-EASTERN SECTION.—Tuesday, December 12, at 7.15 p.m., in Armstrong College, Newcastle-on-Tyne. Paper on "The Heavy Oil Engine," by Mr. J. Calderwood.

THE JUNIOR INSTITUTION OF ENGINEERS.—Tuesday, December 12, at 7.30 p.m., at Royal United Service Institution, Whitehall. Presidential Address by Captain H. Riall Sankey, C.B., C.B.E., R.E. (retired). "The Utility of Theory to the Practical Man."—Friday, December 15, at 7.30 p.m., at 39, Victoria-street. Lecturette, "Notes on Printing Machinery," by Mr. W. T. Marchment, Member.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, December 12, at 5.30 p.m., at the House of the Royal Society of Arts, John-street, Adelphi, W.C. 2, the following paper will be read—"Some Aspects of the Occurrence of Oil in Russia," by Mr. T. G. Madgwick, M.Inst.M.M.

THE BIRMINGHAM METALLURGICAL SOCIETY (INCORPORATED): WOLVERHAMPTON BRANCH.—Wednesday, December 13, at 7.15 p.m., at the Technical School, Old Hall-street, Wolverhampton. Paper by Mr. C. E. Turner, B.Sc., "Fuel Oil and its Applications."

THE SOCIETY OF GLASS TECHNOLOGY.—Wednesday, December 13, at 2.30 p.m., in the Physical Chemistry Theatre, University College, Gower-street, London, W.C. 1, a paper entitled "Improvements in the Design of Recuperative Glass Pot Furnaces," will be read by Mr. T. Teisen, B.Sc. A general discussion will follow on "The Use of the Autoclave in Testing Glass."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, December 14, at 6 p.m., in the Lecture Theatre of the Institution, Savoy-place, Victoria Embankment, W.C. 2. "Electric Arc Welding Apparatus and Equipment," by Mr. J. Caldwell, Member.

THE OPTICAL SOCIETY.—Thursday, December 14, at 7.30 p.m., at the Imperial College of Science and Technology. An addition to Rule 7 (Corporate Membership) will be proposed. "A Large Aperture Lens not Corrected for Colour," by Mr. T. Smith, M.A., F.Inst.P.; "The Optical Cosine Law," by Mr. T. Smith, M.A., F.Inst.P. Demonstrations will be given of the Measurement of the Internal Diameters of Transparent Tubes, and a Simple Differential Refractometer for Liquids, by Dr. J. S. Anderson, M.A., F.Inst.P. There will also be an exhibit and description of a Constant Bubble (unaffected in length by changes of temperature), by Messrs. E. R. Watts and Son, Limited.

THE NORTHAMPTON ENGINEERING COLLEGE ENGINEERING SOCIETY.—Thursday, December 14, at 5.30 p.m., at the College, when Mr. M. L. G. Semple will read a paper on "Steam Turbines."

THE BIRMINGHAM METALLURGICAL SOCIETY (INCORPORATED).—Thursday, December 14, at 7.15 p.m., at the Assembly Room, Chamber of Commerce, New-street, Birmingham, "Some Aspects of the Mechanical Treatment of Metals," by Mr. F. Johnson, D.Sc.

THE INSTITUTION OF STRUCTURAL ENGINEERS.—Thursday, December 14, at 7.30 p.m., at Denison House, 296, Vauxhall Bridge-road, S.W. 1, a paper on "The Strength of Rectangular Slabs," will be read by Mr. A. Ingerslev, B.Sc.

THE INSTITUTION OF CIVIL ENGINEERS: YORKSHIRE ASSOCIATION.—Friday, December 15, in the Philosophical Hall, Leeds. Paper by Mr. G. B. Jones, on "Corrosion."

THE INSTITUTION OF PRODUCTION ENGINEERS.—Friday, December 15, at 7.30 p.m., at the Engineers' Club, Coventry-street, W. 1. "The Production Engineer," by Mr. H. E. Honer.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—Friday, December 15, at 6.30 p.m., at the Engineers' Club, Coventry-street, W. 1. Paper by Mr. O. T. Gnosspelius, A.C.G.I., A.F.R.Ae.S., on "Experimental Data without Wind Channel."

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, December 15, at 6 p.m., "Reclamation Plant and Its Operation," by Mr. Gascoigne Lumley, I.S.O., Member.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—The joint official audit by the owners' and miners' accountants shows that in October the cost of production at 17*s.* 11*d.* per ton was slightly lower than in September, notwithstanding the inclusion in the wages expenditure of the Lord Buxton subsistence award. The output showed an increase of 70,000 tons, but the proceeds were 7*d.* per ton less as the result of a slump in the price of smalls, in consequence of depression in the coke and patent fuel industries. Exports of coal as cargo last week amounted to 530,000 tons, or 37,000 tons more than in the previous week. The bulk of the shipments as usual went to France, 204,500 tons going to that country. Shipments to Italy totalled 49,200 tons, to South America 69,100 tons, to Spain 36,600 tons, to Portugal 9,700 tons, to Greece 15,800 tons, to British coaling depôts 47,000 tons, to the United States 7,200 tons and to "other countries" 90,800 tons. For the first week since August 4 last there were no exports to Canada. Market prices of coal have advanced considerably during the past week, and free supplies are now very scarce. The majority of the collieries are booked up till the end of the year and with an abundance of shipping in dock new business is limited. For best Admiralty large 28*s.* 6*d.* is firmly demanded, 28*s.* for seconds and 26*s.* 6*d.* to 28*s.* for Monmouthshires, which prices represent a rise of 1*s.* to 2*s.* on the week. Smalls are also much firmer on the basis of 17*s.* 6*d.* for best steams compared with 16*s.* a week ago, and from 12*s.* to 16*s.* for other grades against 10*s.* to 12*s.* Dry large coals are, however, weaker on a lessened demand due to the easiness developed in anthracites. Best dry large is now offered at 28*s.* and ordinaries at 27*s.* A fair amount of business over next year has been booked up of late at 26*s.* 6*d.*, 26*s.* 9*d.* and 27*s.* for best Admiralty large, 25*s.* 6*d.* for Western Valley Monmouthshires, and 24*s.* for Eastern Valley large, and 16*s.* for best steam smalls. An over-supply of tonnage at the docks is still causing collieries much difficulty. Throughout the past week some 50 vessels have been daily waiting for loading berths, and many others have been waiting orders. Production is now in excess of the capacity of the railways and the docks, and efforts are being made to induce the coal trimmers and tippers to work a third shift in order to cope with the increasing volume of shipments.

Iron and Steel.—Exports of iron and steel goods last week totalled 13,722 tons, compared with 10,317 tons in the previous week. Shipments of black plates amounted to 2,299 tons, against 1,565 tons; tin plates to 5,261 tons, against 5,409 tons; galvanised sheets to 788 tons, against 1,375 tons; and other iron and steel goods to 5,374 tons, against 1,968 tons.

Shipbuilding Contracts.—Richard W. Jones and Co., Newport, have placed a contract with Burntisland Shipbuilding Company, Limited, for two steamers of 4,300 tons deadweight each, which are to be engined by the North-Eastern Marine Engineering Company, Limited, and Mordey, Jones and Co., Limited, Newport, an order for a 3,000-tonner with J. L. Thompson and Sons, Limited, Sunderland.

BASIS OF GAS CHARGES.—The President of the Board of Trade has appointed a Departmental Committee to inquire and report as to the method of charging for gas on a thermal basis. Sir Clarendon Golding Hyde is the chairman. The secretary is Mr. W. H. L. Patterson, Board of Trade, Great George-street, S.W.1, to whom communications should be addressed.

THE LATE MR. HERBERT WOODVILLE MILLER.—We regret to announce the death of Mr. Herbert Woodville Miller, which occurred on the 4th inst., in his fifty-seventh year. Mr. Miller was engineer and managing director of the Kensington and Knightsbridge Electric Lighting Company, with which company he had been connected throughout the whole of his professional career.

ROYAL INSTITUTION.—A general meeting of the members of the Royal Institution was held on Monday afternoon (December 4), Sir James Crichton-Browne in the chair. Sir Arthur Keith was elected secretary in succession to the late Colonel E. H. Grove-Hills. Professors Urbain (Paris), Ehrenfest (Leyden), Knudsen (Copenhagen), Bjerknes (Christiania) and Dr. Irving Langmuir, were elected honorary members. Miss Norah Forman, Mr. F. Hyde, Mr. J. B. Kramer, Mr. Alfonso Marconi, Mr. J. M. S. Marriner, Dr. R. B. Owens and Miss T. Thomas were elected members.

12,000-I.H.P. ROLLING MILL ENGINE FOR THE MOSSEND STEEL WORKS.

CONSTRUCTED BY MESSRS. MARKHAM AND CO., LIMITED, ENGINEERS, CHESTERFIELD.

(*For Description, see Page* 704.)

Fig. 38.

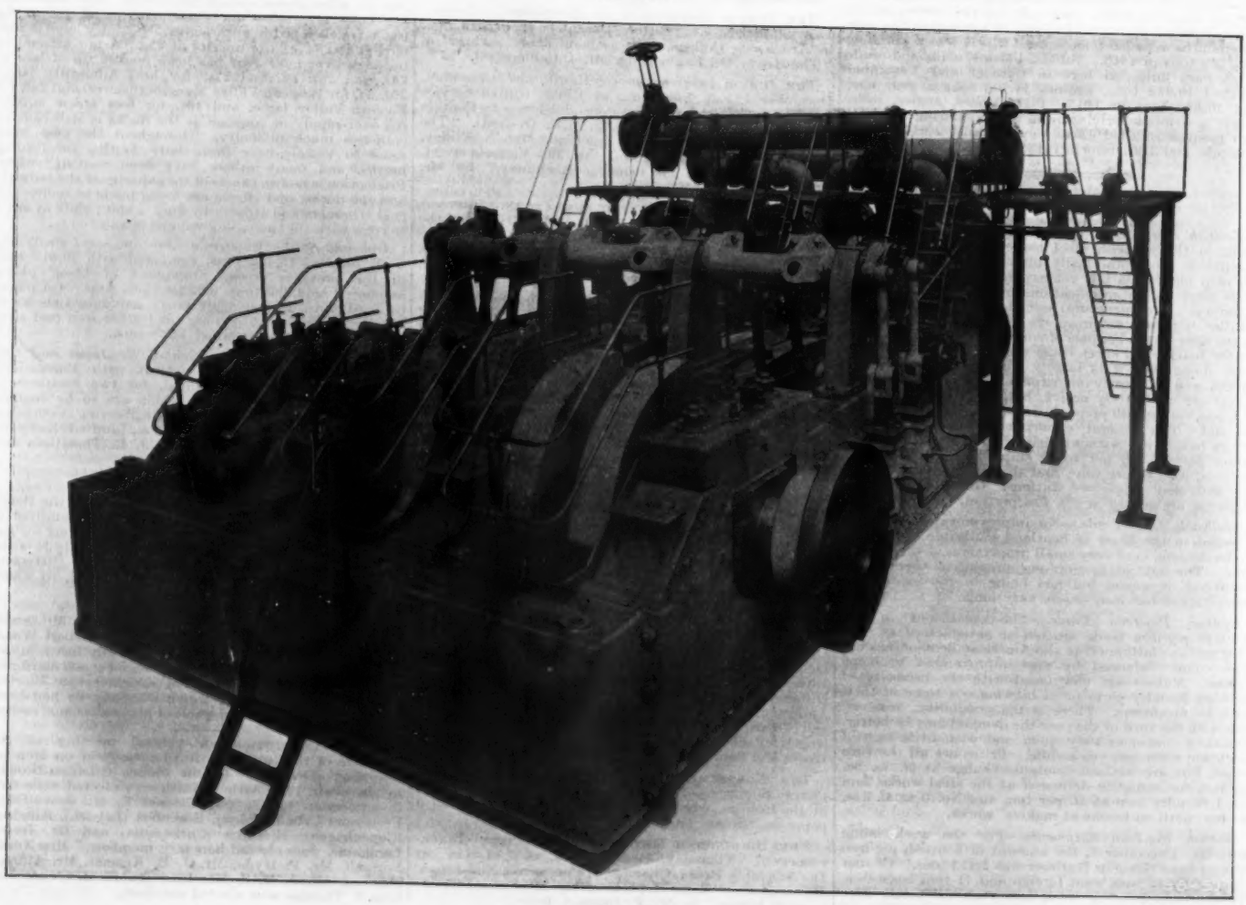


Fig. 39.

12,000-I.H.P. ROLLING MILL ENGINE FOR THE MOSSEND STEEL WORKS.

CONSTRUCTED BY MESSRS. MARKHAM AND CO., LIMITED, ENGINEERS, CHESTERFIELD.

(*For Description, see Page* 704.)

Fig. 40.

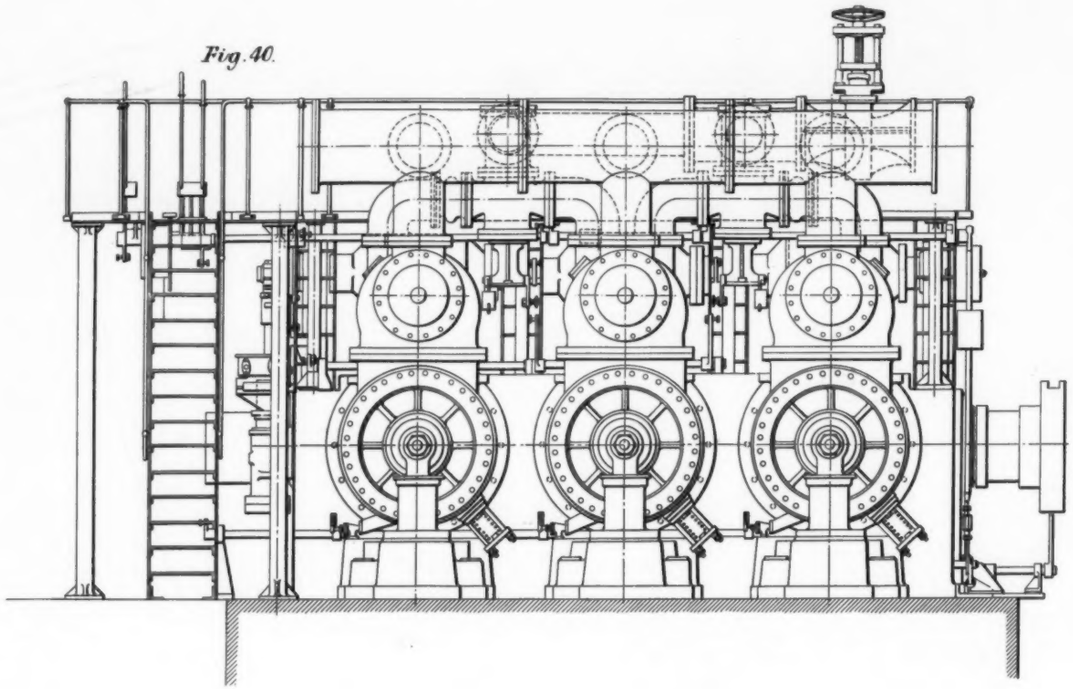
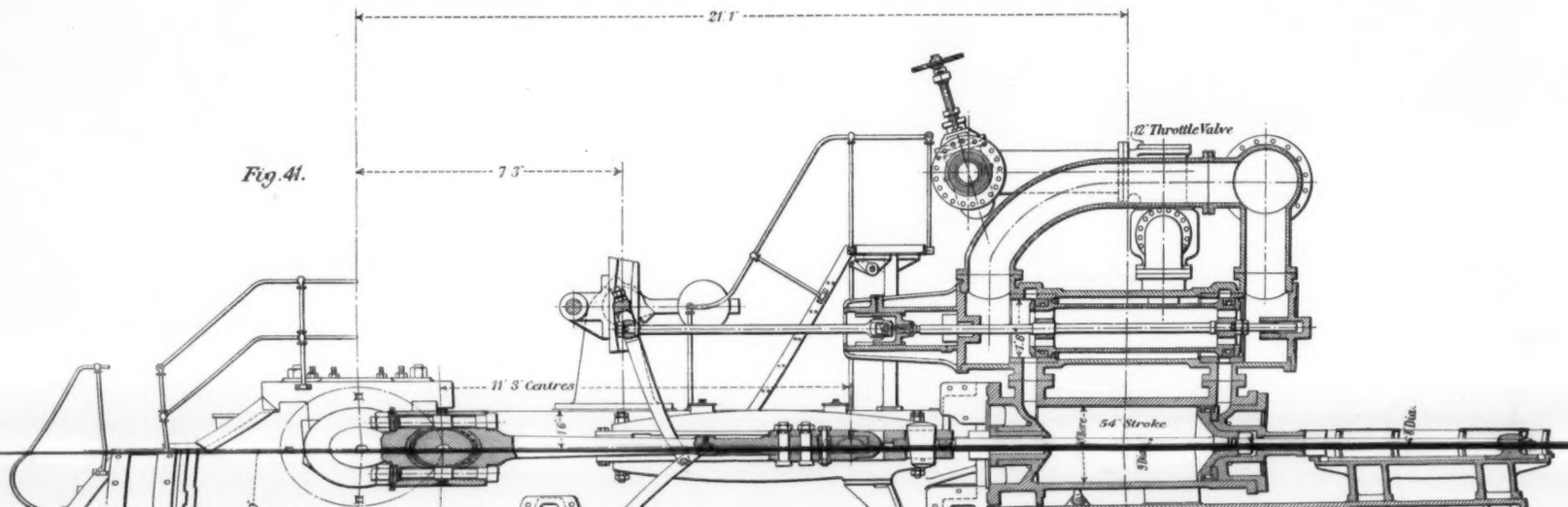


Fig. 41.



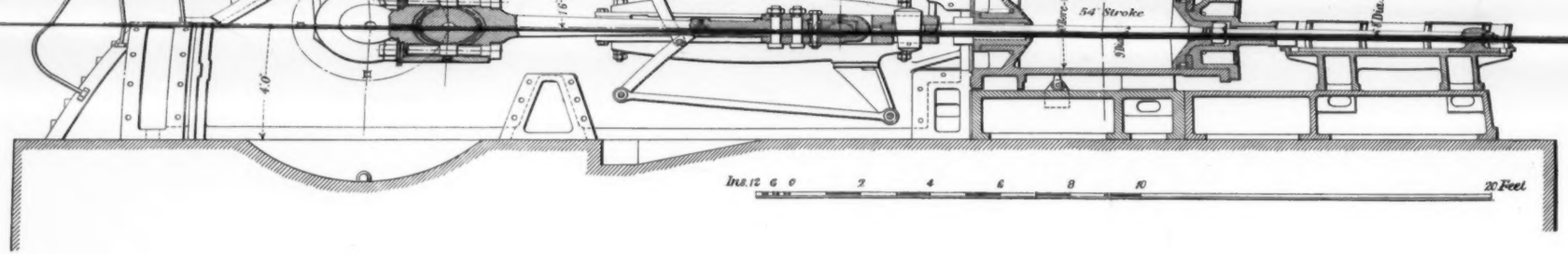
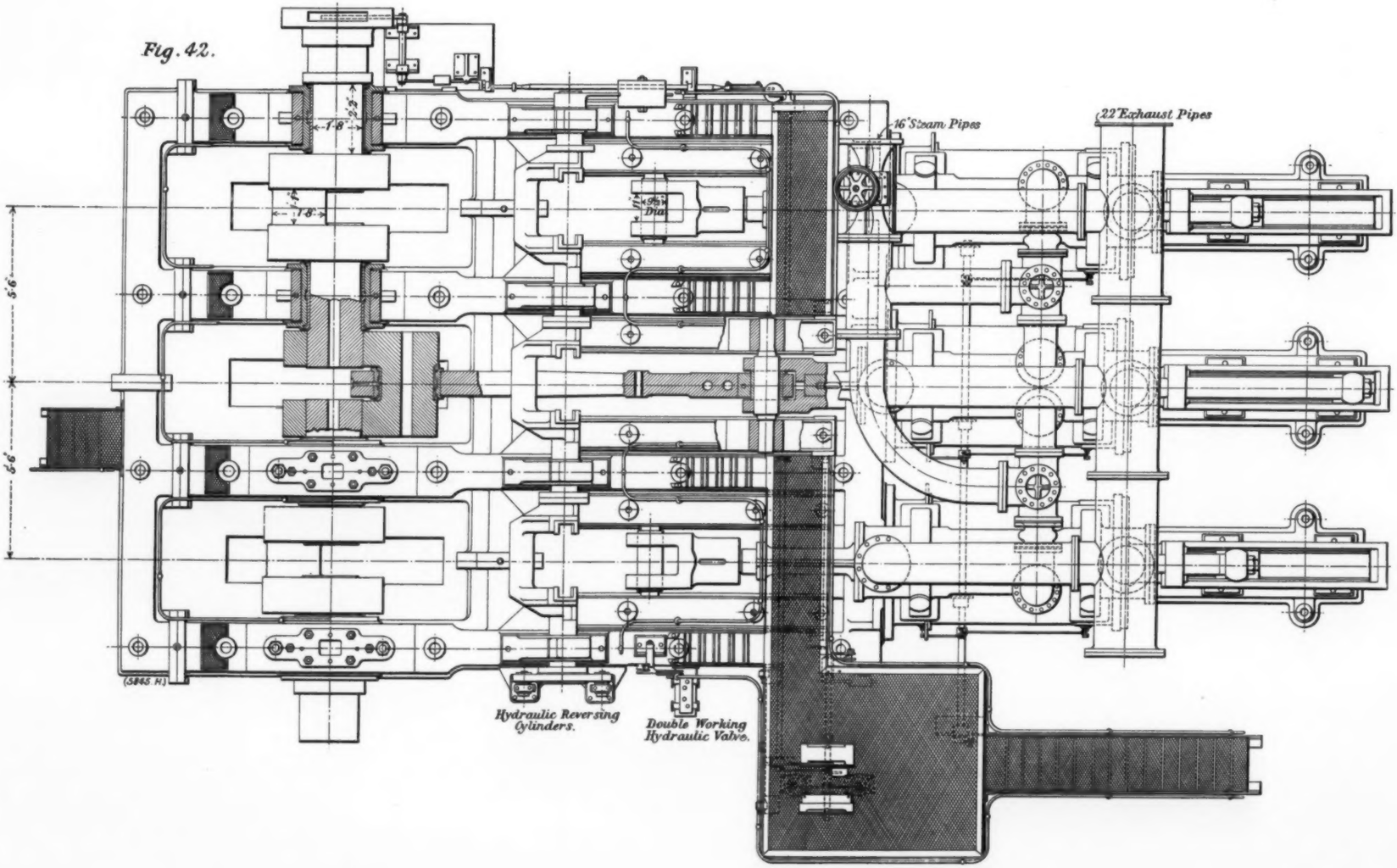

54" Stroke
4'0"
Ins. 12 6 0 2 4 6 8 10 20 Feet

Fig. 42.


16" Steam Pipes
22" Exhaust Pipes
5'6"
5'6"
1'8"
1'8"
(5845 H.)
Hydraulic Reversing Cylinders.
Double Working Hydraulic Valve.

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ENGINEERING.

FRIDAY, DECEMBER 8, 1922.

THE THEORY OF LUBRICATION.

GENERAL reasoning is so often at fault as almost to justify the conclusion that general reasoning is generally wrong. A classic example was afforded when the late Sir George Airey concluded from general consideration that the conditions for observation would be more favourable at the transit of Venus which took place in 1874 than in that due eight years subsequently. A more detailed study of the problem by the late R. A. Proctor, after arrangements had already been made, is stated to have proved that the very reverse was the case. Similarly, some engineers, after a cursory study of Osborne Reynolds' theory of lubrication, decided from general reasoning that the conditions on which it was founded were seldom realised in practice, basing their conclusions largely on the circumstance that, according to Reynolds' theory, the frictional resistance developed depended on the viscosity of the lubricant, whilst practical experience showed that the actual coefficient of friction, even in a fully-lubricated bearing, was nearly the same whatever the lubricant used.

The fallacy of this argument was very thoroughly exposed in the able and interesting Thomas Hawksley lecture delivered to the Institution of Mechanical Engineers last Friday evening by Dr. Stanton, of the National Physical Laboratory. What Reynolds' critics had overlooked was that, according to the theory, the friction of a bearing, was also a function of the thickness of the oil film, and, with stated conditions of load and speed, this thickness was less the less the viscosity of the lubricant. Dr. Stanton gave in his lecture the results of a calculation of the frictional resistance of a bearing run at the same load and at the same speed with different lubricants. When the viscosity of the lubricant was 0·233 the calculated coefficient of friction came out as 0·00094, whilst when the viscosity was 0·824, or nearly fourfold, the coefficient of friction was 0·00099, or only some 5 per cent. more.

The very careful and ingenious experiments described in the lecture very thoroughly vindicate the wide applicability of Osborne Reynolds' theory, but at the same time thoroughly substantiate the objections raised to the policy of the Committee on Lubricants in attempting to experiment on an ordinary journal bearing. It appears from the lecture that all the troubles anticipated by the opponents of this course were encountered, and that it was impossible to obtain figures sufficiently accurate for a comparison with theory, until the attempt to reproduce practical conditions was abandoned, and in the end it was found expedient to make the bush 6 per cent. larger than the journal, so that the effective bearing area subtended but some 20 degrees.

In the earlier experiments in which practical conditions were approximated to, qualitative agreement with the theory was obtained, but not even the exceptional experimental skill and ingenuity of the lecturer sufficed to get reliable quantitative figures. This was in the main due to the circumstance that the brass distorted under its load, and since the distribution of pressure in the oil film depends upon the difference of the radii of brass and journal, this distortion altered the radius of the brass by an amount which was a large fraction of the clearance. In ordinary high-speed bearings the brass is bored to a diameter which exceeds that of the journal by four mils per inch. At Teddington it was, as stated, found requisite to increase this allowance to 60 mils per inch, which made it permissible to assume that the distortion of the brass under its load could be neglected, thus making practicable a quantitative comparison with theory. Under these extremely modified conditions, the effective length of the brass is settled by the apparatus itself. The effective part of oil film only extends a short distance on each side of the point of closest contact, and the conditions correspond almost exactly to those which occur in the lubrication of gear teeth. Mathematically, the formula for the pressure distribution is identically the same, save for a multiplicative constant, which is due to the fact that when a cylinder rolls over a flat surface the lubrication is twice as efficient as it is when the oiled surface is slid underneath a fixed cylinder.

On this head much misapprehension prevails. Some engineers have got obsessed with the idea that for lubrication to be effected on Osborne Reynolds' principle it is necessary for oil to be "dragged in" between the opposing surfaces. As a matter of fact the oil pressure that keeps the surfaces apart is due to the objection of the oil to be extruded from between them, and hence, if a cylinder rolls over an oil covered plane, lubrication is effected on Osborne Reynolds' principle just as much as it is in the case of a journal, although there is no "dragging in" of the oil. In short, the oil film is already there, and before it can be extruded the cylinder has rolled on a point where the film retains its original thickness.

It follows from what has been said above that the Teddington experiments are more directly applicable to the lubrication of gear teeth than to bearing lubrication, and they have definitely settled one very important point. In an article, published in our issue of August 11, 1915, page 119, it was shown that for the conditions realised at the National Physical Laboratory, theory provided two alternative curves for the distribution of the pressure on the oil film. The film, being unable to withstand tension, might break off at the point of closest contract, in which case the pressure would fall there abruptly to zero. On the other alternative the operative film would extend for some little distance on the "trailing" side of the point of contact, and where it ceases to be effective the tangent to the pressure curve becomes horizontal. This is somewhat the more favourable of the two alternatives mathematically possible, and it appears from Dr. Stanton's experiments that it represents the actual facts. The curve of pressure as plotted from the observations corresponds, it turns out, very closely to that reproduced on page 600 of our issue of May 7, 1920, due allowance being made for the fact that for considerations of mathematical convenience it was considered permissible to treat that curve as extending to infinity on the leading side of the point of closest contact. As indicating the accuracy and consistency of Dr. Stanton's observations,

it may be noted that it was found practicable to "differentiate" the experimental curve, a procedure which is very seldom legitimate. In the present case, however, not only were the observations very consistent, but the tangents thus determined were drawn at points of contrary flexure, at which a tangent has three consecutive points coincident with the curve. This circumstance materially improves the possibility of a satisfactory "fix" if it be permissible to adapt a term used in navigation.

In Dr. Stanton's experiments the maximum pressure observed amounted to about 3½ tons per square inch, the lubricant being castor oil, and the least thickness of the oil film was found to be 0·000046 in. It is interesting to compare these figures with the corresponding values for the film between the teeth of marine reduction gears, as determined by calculation and tabulated on page 453 of our issue of October 15 last. In the case of the ss. Melmore Head the computed thickness of the oil film was 0·000035 in., and the maximum pressure in the film 23,100 lbs. per square inch. In general, however, the average film thickness turns out to be somewhat greater than that found in the Teddington experiments which is in part due to the better lubrication due to the rolling motion, although the "effective" curvature of the opposing surfaces is also a factor in the problem, as is also the relative speed.

The high pressures at Teddington were obtained with castor oil and with heavy cylinder oil. When the attempt was made to carry the same load with lighter oils, such as sperm, the vibration became so great that the experiment had to be abandoned for fear that "seizing" might occur and the bearing be spoiled. The exact converse of this is reported to have occurred with certain high-speed bearings of large diameter, in which the surface speed was of the order of 100 ft. per second, and the clearance between brass and journal 4 mils per inch. In this case it is stated that heavy vibration occurred until the oil warmed up, thereby reducing its viscosity. On this condition being attained the bearing ran steadily and quietly. Unfortunately, complete data are not available, and it is not clear whether the vibrations were encountered merely in running up to speed or continued afterwards. If the first-named hypothesis be correct, the explanation may possibly be found in the fact that, with a bearing at rest, the least distance between brass and journal is at the bottom of the brass, but in the stable running position the point of closest contact lies to the trailing side of the brass, and to attain to this position it is necessary for the shaft to be lifted. This operation does not in all cases appear to be effected quietly as the shaft after beginning to lift, sometimes slips back again, and it is only after a certain speed is attained that quiet running is achieved. It is at least conceivable that the vibrations noted, when it was attempted to run the Teddington bearing with light oils and heavy loads had a similar origin, but other explanations are certainly possible.

One very important observation at the National Physical Laboratory was that, provided the journal was run up to speed before the load came on, there was no wear of the brass, the two solid surfaces being completely separated by the film of oil. Another highly important conclusion reached was that "seizing" might occur whilst the oil film was still very many molecules thick. This observation accords very well with the view repeatedly advanced in these columns, viz., that lubrication fails and a bearing seizes, when the shear stress on the oil exceeds a certain limit, which depends on the physical properties of the oil and of the bearing metal. In order that oil may be dragged in between the opposing surfaces it must adhere to them, but the strength of the bond will vary with the lubricant and with the metal. Should the shearing forces developed in the film exceed the strength of this bond slip will occur and, the pressure being no longer maintained, the opposing surfaces will come into contact and "seizing" occur. A rise of temperature may be expected to weaken the bond and to promote "seizing," the more especially as at the same time the viscosity of the lubricant will be diminished, thus thinning the film and increasing the shear stress. On this view the superiority as lubricants of animal and vegetable oils lies in the fact that they form a stronger bond with the bearing metal than do the mineral oils, a fact which Mr. R. M. Dally appears to have been the first to observe.

THE COUNTRY 'BUS.

PASSENGER transport to-day in rural areas presents a number of peculiar features which did not exist in the days of our forefathers. Not so long ago the stage coach, a few phaetons, the squire's dog-cart and the farmer's gig, supplemented by the more humble seat in the carrier's cart, or the still less ostentatious means of locomotion provided by Shanks' mare, sufficed for the needs of those whose business or pleasure required them to journey from one place to another. The rise of the towns, and the development of the railways, which did much to foster passenger traffic in their early days by absurdly cut rates, resulted in the gradual spread through country places of a wish for something more than the occasional visit to the nearest market, or a journey by coach to the county town, or perhaps, even to the wonderful city of London. The old idea that anything in the way of a long-distance excursion was an undertaking of grave physical risk, not to be lightly undertaken, not to mention the moral peril of "going out into the world," has now altogether dispersed, though it is only quite recently that there were still old folk who had never journeyed by train, and, may be, such could still be found in some of the remotest corners of the kingdom.

The stage coach provided mainly for long distance traffic. Apart from this the movement about the country was mostly due to visits to markets. Both forms of traffic are catered for by the railways to-day. The stage coach has been absolutely eliminated, while the special facilities and additional accommodation provided for local market days has built up to the railways a goodly amount of patronage and brings to the towns far greater crowds than ever visited them before. The number of smaller places served is, however, still limited, though each country station is the collecting point for a good deal of traffic. Many villages of some size are served by good roads, though still distant from any railway. It is not to be expected now that these will ultimately have railway connection. The cost of construction of the normal system makes the proposition an impossible one, while attempts to foster light railway enterprise have so far been abortive in this country. The extension even of tramways into remote rural districts would burden the system with heavy costs of a permanent character which the traffic could ill stand, so that there would appear to be in this rural traffic a field of enterprise peculiarly suited to the motor omnibus. In this form of transport, as Mr. S. E. Garcke pointed out in the paper he read before the Institution of Transport on Monday last, the capital expenditure does not depend upon the miles of route operated, but on the number of vehicles in service, and it is therefore suitable for employment where traffic is so light that heavy capital costs would overload an enterprise. At present, as we all know, the motor omnibus, though subjected to a certain amount of taxation, is not called upon to meet anything like the charges which a railway has to face with regard to the road it runs over, and its contribution, such as it is, is independent of distance traversed. How long this position of privilege will persist, it is impossible to say, but while some advantages to a young industry thus arise to which the older-established systems not unnaturally take exception, the operation of a successful 'bus service is not as a consequence all plain sailing. The road, which is free to them, is also free to any self-appointed rival. The railway has to meet opposition by road, water and air traffic, but other railway competition has largely disappeared. Even when competition was rife between railway companies it was largely concerned with the traffic of certain definite points, while intervening areas were left undisturbed by the state of rivalry which existed.

To-day the motor-'bus often runs on roads alongside the railway, but we concur in what we gather to be Mr. Garcke's opinion that competition of this kind over the greater distances will not last for long. Mr. Garcke points out that the recent extraordinary development of the summer char-a-banc traffic occurred at a time when the railways had not recovered from the effects of the war, and were further suffering the great inconvenience consequent upon the coal strike. That there is still a vast number of people who have a preference for the railways for the longer journeys has been amply proved by the patronage accorded in practically every case in which the attempt has been made to restore pre-war railway services in connection with holiday traffic. There will always be in the future many people who will enjoy a ride by motor in good weather, and to these the motor char-a-banc offers unique opportunities of seeing the beauties of rural districts. No one, for instance, could seriously compare a visit to the Dukeries by railway with a tour by road. These individuals, however, do not bulk so large in number as might be imagined, and in the summer months there will always remain, we hope, to be served a goodly contingent of large and small families with all their holiday paraphernalia which the railways know so well how to handle, but which would be absolutely declined by the motor services.

It is thus not in competition for regular holiday traffic that the motor will be successful; but motor transport can without doubt render a great service to the country by catering for ordinary rural traffic. This involves running over considerable distances and demands above all as Mr. Garcke shows the strictest regularity in operation. The traffic cannot afford a frequent service as is customary, for instance, on a tramway system, and to offset for this absolute adherence to time-table is essential. In this the country 'bus service resembles train working, but unfortunately for the 'bus this introduces considerable drawbacks. On the one hand the omnibus is a small unit, and a heavy rush of passengers on one journey, perhaps at some intermediate point, is difficult to handle without disappointment to the patrons. The 'bus has not the elasticity of the train in this respect. Again, the train can publish its time-table without much harm resulting, but if a motor service follows this custom it is open to any rival to run over exactly the same route just ahead of the best runs of the regular service, and, as the expression is, "scoop" all the traffic. The very success of one service is tantamount to an invitation to rivals, but where one may just make a profit two may, and most likely would, fail, and it may quite possibly be that one which is most deserving of support by reason of its adherence to a regular schedule. Rivalry has existed, of course, on the roads before now. At one time it was a prominent feature of the coaching traffic, but it must be admitted that it is a little hard on a well-conducted service that it should suffer in such ways for its very success. Mr. Garcke would like to see the services licensed and restricted, but we do not think that the country would consider such a proposition. The roads in principle at least are available for all users, and the only ground upon which control is likely is not to enable one company or another to make a profit, but to protect the general public from an excess of motor traffic, or from abuse by the running of unfit cars by unsound concerns intent only on "pirating."

The question of excess of traffic is a very difficult one which so far as we are aware has not yet brought forward any adequate solution. If such excess occurs at the starting point it may be dealt with by a relief car, but if as often happens it quite unexpectedly arises at some intermediate point, unless overcrowding is permitted, many would-be passengers are liable to have to wait over a long interval for the next regular car. This, of course, means disappointment and is detrimental to the service. These rushes are spasmodic; they neither occur at the same time of day, nor regularly on the same day of the week. For the more regular crowds, Mr. Garcke advocates the use of trailers which are now largely adopted on the Continent. He points out that abroad, the London type of omnibus, carrying 36 passengers, is worked with a 16-seated trailer, thus making available for the regular crowded trips a 52-seated unit. There is little doubt that the trailer could be developed to suit most roads in this country. It is, as Mr. Garcke

says, a matter of design, and we are sure that genius sufficient exists here to tackle this problem successfully.

On the whole, Mr. Garcke recommends the larger single-decked vehicle as opposed to the small unit, but he would see it specially designed instead of practically a machine essentially developed for heavy goods transport. Better springing is required, and a reduction of unsprung weight, when even solid tyres on good roads would result in a material reduction in the vibration which in cases is so pronounced. We are pleased to note that, where a large staff is impossible, Mr. Garcke leans towards the management being in the hands of an engineer. There is no doubt that an engineer's training brings out many qualities which are of value in such a position, and a keen man can supplement these as the service develops. One of the main difficulties is the foreseeing of extra traffic, and this can only be provided for by obtaining intelligence from all points of the area served. Much may be done in this direction at small cost, but it will be a very alert official who will not find himself caught occasionally, even then.

NOTES.

British Empire Exhibition.

In the work of organising a complete representation of all the many industries of the British Empire at the great exhibition, which is to be held at Wembley Park, London, from April to October, 1924, the Executive Committee have enlisted the services of representative bodies not only in the arrangements of the general scheme but also in technical committees for all the sectional activities. The space requirements for adequate displays in the various divisions will not be considered before the beginning of the New Year, when, it is hoped, all applications by firms will be in the hands of the organisers. Already it is anticipated that additions will be necessary to one of the two large halls devoted to machinery and to industry; although they cover a total area of 884,000 sq. ft. The activities of the local Chambers of Commerce and of the Federation of British Industries, in interesting their individual members in the Exhibition have been productive of a large number of applications for space. The British Engineers Association and the British Electrical and Allied Manufacturers Association have made themselves responsible for the organisation of all machinery, engineering and electrical exhibits, and chemical exhibits are being dealt with by the Association of British Chemical Manufacturers, with the aid of the Society of Chemical Industry. For purposes of satisfactory organisation a general classification scheme with sections for Food, Raw Materials, Communications, Machinery and Implements, Manufactures, Homes, Education, Science and Art, Recreation, Defence, and Colonisation and Social Economy, has been adopted and these are subdivided into groups. One of the most recently appointed group committees is that concerned with scientific instruments, of which Sir W. Napier Shaw is chairman and Sir Joseph Petavel, vice-chairman. The other members are representative of the designers, manufacturers and users of all types of mathematical, surgical and general scientific instruments. It is hoped that the Royal Society as a measure of support for the Exhibition will form a committee to deal with pure science.

Training for Foremanship.

There is a growing feeling that the needs of industry to-day towards intensive production require that more consideration than has been the case in the past be given to the qualifications necessary for foremanship, with a view to investigating whether better results could not be reached by some form of training for this definite position in our engineering workshops. It is to be admitted that the training in our technical schools and colleges leans decidedly towards the design side of engineering work, and a full knowledge of draughtmanship and of the underlying principles of design governing the determining of suitable forms, sections and dimensions can only be a very considerable asset to anyone in a position of authority in engineering work, but for the specific position of foreman, these are not so essential as other qualifications for which, as yet, there is little opportunity for securing training. In this connection mention may be made of the various subjects of qualities of materials such as special tool steels, machine tool performance, feeds and speeds, fixing of rates and so forth. In this connection the Association for Education in Industry and Commerce propose to follow up their recent report on "Training for Foremanship," by issuing a report on "Vocational Training for Manual Workers in the Engineering Industry." The following committee has been appointed to prepare this report: Mr. W. Daniels, B.Sc., of William Beardmore and Co., Limited, Glasgow; Mr. W. Lang, M.A., of the Albion Motor Car Company, Limited, Glasgow; Mr. C. A. Packer, of G. and J. Weir, Limited, Cathcart, Glasgow; Mr. I. Garvie, B.Sc., of Barr and Stroud, Limited, Glasgow (secretary). To enable this committee to meet regularly and conveniently, its members have been drawn from one locality, but the scope of its inquiries is intended to cover the United Kingdom. In order that the report may be as comprehensive and useful as possible, it is hoped that firms who are providing any organised training for their engineering workers will communicate either with the secretary of the committee or with the Secretary of the Association, Mr. R. W. Ferguson, B.Sc., Messrs. Cadbury Brothers, Limited, Bournville.

Heavy Fuel Oils in Internal-Combustion Engines.

In the opening of his paper on "Some Factors Affecting the Utilisation of Heavy Fuel Oils in Internal-Combustion Engines," at a meeting of the North-East Coast Institution of Engineers and Shipbuilders, on December 1, Mr. Harold Moore, M.Sc., classified the difficulties in burning heavy fuel oils as:—uncertainty of ignition, irregularities in combustion, and troubles caused by the presence of comparatively small quantities of impurities. In the greater number of Diesel engines the compression is adjusted to ensure certain and regular ignition under all conditions when petroleum residua and gas oils are used, but with tar products starting and operation on low load may be uncertain, as the compression temperature may not exceed the ignition one to a sufficient extent. The cooling influences of the blast has a marked effect in increasing the temperatures required for satisfactory ignition. Certain chemical substances cause the suppression of the phenomenon known as "pinking" in petrol engines, and it is anticipated that treating fuel oil for Diesel engines in the same way may increase the velocity of flame propagation. The introduction of a small amount of easily inflammable oil before the main fuel charge, by the use of pilot gear, is one solution of the problem of burning oils of high ignition point. Satisfactory working has been found by Mr. Moore when employing this gear with both pumps delivering tar oils. The presence of bituminous bodies is manifested in the combustion of oils by the production of slow-burning coke accompanied by a smoky exhaust and the deposit of solid matter as well as by an objectionable effect upon the pulverisation of the oil due to the increase in viscosity. The second of these actions may be overcome by a slight preheating of the fuel and the bituminous substances can be precipitated by means of a small amount of petroleum oil before use. Water in the fuel causes irregular combustion, misfires followed by overload conditions are common and the lubricating oil becomes contaminated with tarry substances. With other impurities deposits may be expected on the cylinder walls and trouble may arise with the pulverising devices unless they are of special design.

The Preliminary Heat Treatment of Brown Coals.

That it is a good thing to think of coal as a manufactured article was a contention of Professor W. A. Bone in the course of the second of his Cantor lectures on "Brown Coals and Lignites," at the Royal Society of Arts, on Monday last. The value of the fuel in its natural condition in the earth is represented by the royalty paid to the owner, and is only a very small fraction of the value after mining, when preparation and transport have made it available for use. There are great deposits of lignites in the British Dominions, and as they are in thick seams and easily worked the "cost of manufacture" is low, but the physical properties, such as the disintegration on handling, the high water content, and the low calorific value, all keep down the value of the material as a useful heat-giving substance. Additional costs may be entailed in treatment to up-grade these fuels with a more than compensating appreciation in their value. Experiments conducted by Professor Bone at the Imperial College of Science and Technology, have shown it is possible to enhance considerably the calorific value of the brown coals as well as their usefulness in by-product recovery processes. For the first tests, with Morwell coal from Australia, it was found that heating the fuel out of contact with air to a temperature of about 400 deg. C., after it had been dried at a temperature of 110 deg. C., produced a chemical condensation affecting the cellulosic constituents. During the process a reduction of weight takes place due to the elimination of 5½ per cent. of water and 6½ per cent. by weight of gases. The gas liberated contained 88½ per cent. of carbon dioxide, nearly 5 per cent. of nitrogen, over 4 per cent. of carbon monoxide and lesser amounts of sulphuretted hydrogen and methane. It is believed that the chemical condensation taking place in this action is comparable with what has gone on for ages in the earth and led to the production of bituminous coal from the earlier brown coals. The reduction of the oxygen present and the consequent increased proportion of carbon are marked by a change in the calorific value of the coal from 5,600 to 6,360 kilogramme centigrade units per kilogramme (10,080 to 11,450 British thermal units per pound). While the coal loses about one-eighth of its original weight the whole of the potential heat value is retained. Later research work has corroborated these results with other brown coals. The up-grading of this type of fuel may be produced by the use of the waste heat of flue gases.

Hygienic Features of Air Travel.

Few will dispute the statement that the problem of maintaining an adequate supply of air to passengers in an aeroplane cabin without causing discomfort from draughts and cold is one of some considerable difficulty. At the same time, aerial transport has now reached a stage of development when a determined effort should be made to solve it, since many of the unpleasant symptoms of which travellers by air complain can be traced to imperfect ventilation. The difficulties of the problem, and other matters affecting the popularity of air travel, are clearly put in some medical notes in connection with commercial aircraft just issued by the Air Ministry, the notes including some suggestions as to possible improvements which are well worth the attention of aircraft designers. It is advocated, for instance, that cabins should be ventilated by aspiration with the inlets arranged low down and towards the after end of the cabin. In connection with the warming of cabins by drawing the air over the exhaust pipe, it is pointed out that air heated to temperatures exceeding 200 deg. C. by direct contact with metal becomes "devitalised" and causes discomfort to persons breathing it. The heat of the exhaust can, however, be satisfactorily employed for the purpose provided that a double jacket is used round the exhaust pipe to prevent the temperature of the air from exceeding the above-mentioned limit. It is further pointed out that for airship cabins steam heating might be employed, the steam being raised in a small high-pressure boiler heated by the exhaust gases. The weight of the necessary apparatus would appear to prevent the employment of steam heating on aeroplanes, but apart from this serious drawback the system has many advantages. The importance of excluding the odours of petrol, oil and dope from passenger cabins needs but little emphasis and the fatiguing effects of long-continued noise and vibration are fully realised. Their elimination is, however, no simple matter, and the designer will find little help from the notes in this respect. It is suggested that the best methods of dealing with the trouble of air sickness are attention to the points referred to above, flying at an altitude at which "bumps" are small and infrequent, and consideration of the general comfort of passengers. To enhance the latter, one of the suggestions put forward is that means might be

provided to enable the pilot to converse with the passengers. On this point, our view is that the pilot's mind is, or should be, fully occupied in attending to the safe navigation of the machine, and that this might be prejudiced, to some extent, by diverting his attention to other matters. The question of lavatory accommodation on passenger aeroplanes is considered and the design of apparatus that has proved satisfactory is illustrated in an appendix to the notes which are obtainable from H.M. Stationery Office, price 9*d.* net.

Motor Headlights.

It is acknowledged to be quite time something was done to regulate motor headlights, and particularly to prevent glare from unnecessarily powerful lamps. Glare certainly has caused a number of accidents. "The man with powerful head lights never comes to any harm, and never runs anybody down, but he is indirectly responsible when another car rushes from behind into a man on a push bicycle." Substituting "rarely" for "never," we agree with those words which Commander T. Y. Baker used in the course of a discussion on "Motor Headlights," held by the Optical Society last summer. This discussion has now been published by the society in pamphlet form. A large variety of good and indifferent headlights were described and exhibited on that occasion, when Mr. J. W. T. Walsh, of the National Physical Laboratory, opened the discussion by a paper on the "Glare from Motor Headlights." The question appeared to be ripe for legislation even before the war. During the war all powerful lights were forbidden; there was no restraint afterwards. The Ministry of Transport has not gone beyond making recommendations; the Paris International Commission on Illumination of 1921 reached no conclusion, and in America, where rules have been drawn up, each State acts more or less independently in these matters. The problems are, no doubt, complex. The driver requires a good light, straight, mainly ahead, but also sideways. Absolute brightness is of less importance than sensibility to contrast, but with decreasing brightness that sensibility diminishes very rapidly. The light is not wanted high up, except for reading signboards and avoiding tree, bushes and arches. Hence the general recommendation of restricted beams which throw most of the light on the road. To allow a beam of a height of 5 ft. from the ground at 100 yards from the lamps, as is often proposed, does not afford much protection from glare even to the man of average stature, especially on ascending roads. Yet beam restriction is the best safeguard available, and it can be attained in many ways. Sir Howard Grubb uses a diaphragm and tiers of lenses; Mr. Herbert Ryland an ellipsoidal mirror and lenses; the paralenses of Mr. John Hall are sections of plano-spherical lenses. Mr. A. Whitehead places a peculiar metal filament in a deformed paraboloid mirror; Mr. H. C. Gibson recommends a pin-hole focuscope and a conical reflector; Mr. H. Hoare Ward makes the light focus adjustable; Mr. H. J. Simpson uses prismatic slats, and Messrs. George Kent employ a movable rectangle of smoked glass in a pivoted frame. Mr. C. G. Smith studs his plane lamp glass with many hemispherical knobs, and the Zeiss works, of Jena, provide the glass with ribs, vertical and arc-shaped, and pull a hood of frosted glass over the bulb when strong illumination is not needed. Their mirrors are parabolic and made of glass, silver-backed. Metal mirrors are easily spoiled. Mr. A. A. Sandbrook reverses the lamp when the glare is to be reduced, others make the lamp height adjustable. Anti-glare attachments to the lamp front are not liked, and some of the lamps mentioned are expensive. One point was hardly touched upon during the discussion, viz., the speeds which have led to the demand for headlights of 10,000 candles and more, though most speakers acknowledged that the whole question was too much debated from the standpoint of the motorist, and too little from that of the patient public.

British Coal Output.—The coal output for the week ended November 25 was 5,471,800 tons, as compared with 5,376,000 tons the previous week, and 4,673,000 tons in the corresponding week last year.

MACHINERY AT THE SMITHFIELD SHOW.

Although the exhibition of edible animals is the primary attraction of the annual show of the Smithfield Club, agricultural machinery and implements have always taken a prominent place in the display. This year, as usual, the Royal Agricultural Hall, at Islington, contains a representative collection of agricultural machinery, the whole of the available space being taken by firms whose products appeal especially to those interested in the cultivation of the land. The Smithfield Show has always been noted for the wonderfully fine finish of the machinery exhibited, the fact of everything being under cover and stationary encouraging makers to compete with each other in perfection of workmanship. The characteristic Smithfield finish did not consist in a mere cheap shininess, but represented craftsmandship of a high order, as well as an artistic sense of mechanical fitness. Parts which were nominally flat were really so, and those which were curved had a true geometrical form, so that however light struck the polished surfaces, the eye was never offended by visible imperfections. One has regretfully to note that workmanship of this kind appears to be passing. The Smithfield traditions are still observed by a few of the famous Lincolnshire firms, Messrs. Clayton and Shuttleworth, Limited, Marshall, Sons and Co., Limited, Messrs. Robey and Co., Limited, and a few others deserving honourable mention, but much of the "show finish" now exhibited would not have passed muster a few years ago, and a good proportion of the machinery shows little, if any, attempt to emulate the appearance which used to be characteristic of this particular exhibition. Much of this decline is due no doubt to the steam engine in its various forms becoming relatively less prominent at Smithfield. The agricultural tractors and the cheaper types of oil and petrol engines now occupy a considerable space, and these, especially the imported varieties, have never been noted for excellence of finish.

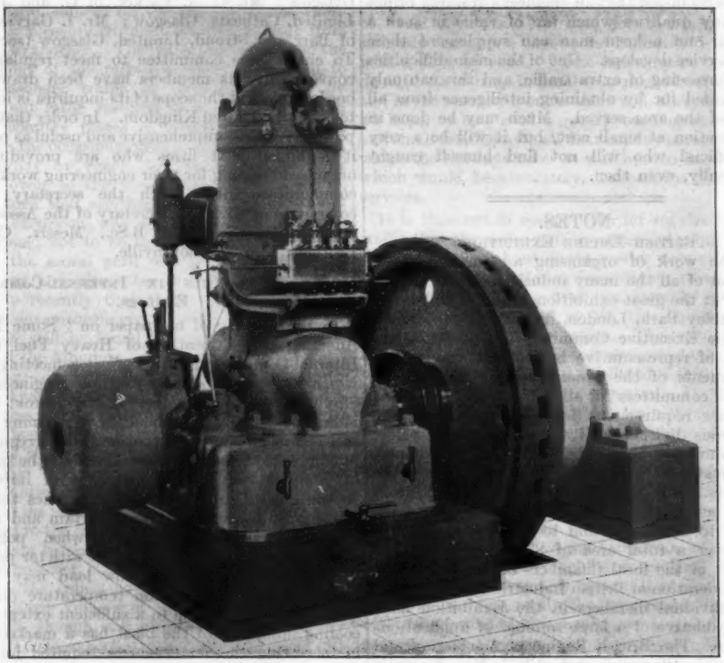


Fig. 1. 30-B.H.P. Crude Oil Engine: Messrs. Marshall, Sons and Co., Limited, Gainsborough.

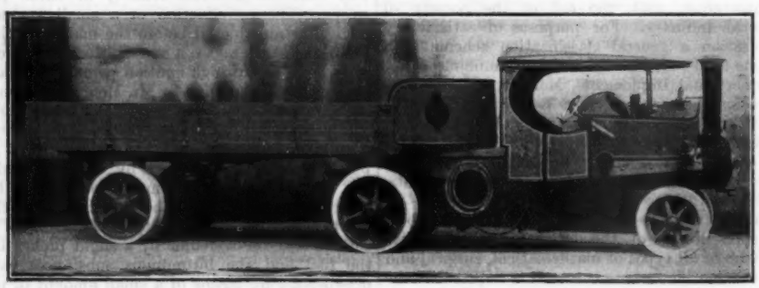


Fig. 2. Six-Wheeled Steam Wagon: Messrs. Robey and Co., Limited, Lincoln.

There are not many novelties at Smithfield this year, most of the important machinery having been illustrated in these columns on previous occasions. Among the agricultural tractors a new design is exhibited by the Saunderson Tractor and Implement Company, Limited, of Bedford. This is a lightweight machine, weighing only 27 cwt. and capable of pulling a three-furrow plough in average land. The design is original in many respects. The engine is of the two-cylinder four-cycle water-cooled Vee type, with overhead valves. A two-speed and reverse gear is constructed as part of the engine unit, the drive being thence to the differential and from the latter to the hind-wheels by means of roller chains. Roller bearings are fitted to the connecting rod big-ends and main bearings and elsewhere throughout the machine. The engine cylinders are

4½ in. bore by 6 in. stroke, and develop 20 b.h.p. The tractor, which appears a thoroughly sound machine, is sold at the low price of 195*l.*, and the makers guarantee that the cost of replacements, due to fair wear and tear, shall not exceed 5*l.*, 10*l.* and 15*l.* respectively for the first three years from the date of purchase.

The so-called semi-Diesel oil engine, which is essentially a hot-bulb two-cycle engine with moderate compression, appears to be gaining in favour amongst agricultural users, and a tendency towards the vertical type is noticeable. Messrs. Clayton and Shuttleworth, of Lincoln, and Messrs. Marshall, Sons and Co., Limited, of Gainsborough, are both now making vertical engines of this kind in addition to the horizontal pattern with which their names have been associated. Other firms showing such engines are Messrs. Robey and Co., Limited, and Messrs. Penney and Porter, Limited, both of Lincoln. We illustrate the Marshall vertical engine in Fig. 1, on page 716. This particular engine develops 30 b.h.p. at 325 r.p.m., its cylinder dimensions being 11¼ in. bore by 13 in. stroke. The type is standardised with four cylinder sizes, and with one, two or four cylinders, covering a range of from 30 b.h.p. to 300 b.h.p. The engines will work with crude oil up to 0·92 specific gravity, the fuel consumption being less than half a pint per brake horse-power-hour. Heavier oils can be used if a pre-heating apparatus is fitted. No water injection is necessary at any load nor is any provision made for this. The absence of any valves in the cylinder, and the general simplicity of design of these engines, make them particularly applicable to purposes where unskilled labour only is available, and this feature no doubt accounts for their popularity, even more than their economy in fuel.

The desirability of increasing the capacity of the steam wagon, especially as regards the transportation of bulky goods, soon led to the use of an attached trailer, but there seems now a decided tendency towards the development of a six-wheeled vehicle. Such vehicles generally consist of a modified trailer, the front wheels of which have been removed, and the fore part of the body mounted on a pivoted support on the chassis of a steam wagon. To effect such a combination various minor modifications, particularly of the trailer part, are necessary if the whole is to behave as a satisfactory unit, and Messrs. Robey and Co., Limited, of Lincoln, among other makers, have turned their attention to vehicles of the type in question. We illustrate in Fig. 2, page 716, the Robey six-wheeled steam wagon as exhibited at Smithfield. The front portion is an adaptation of the firm's standard 5-ton wagon, which has been fully described in our columns, and Messrs. Robey's long experience with both steam wagons and trailers is sufficient guarantee that the combination will fulfil the conditions of road service. The same company also exhibit one of their vertical crude-oil engines of the type illustrated in Fig. 3. The engine operates on the two-cycle principle and will use any kind of crude oil as fuel without water injection. The vaporiser is readily detachable for cleaning. It has to be heated at starting by means of a blow-lamp, as is the case with all engines of this type, but once the engine is running the temperature of the vaporiser is automatically maintained by the heat of the explosions. A centrifugal governor fixed directly to the crankshaft, controls the speed by varying the stroke of the eccentric which works the fuel pumps, thus regulating the amount of oil according to the load on the engine. Single-cylinder engines of the type illustrated are made in sizes from 8 b.h.p. to 50 b.h.p., and with two, three or four cylinders from 24 b.h.p. to 280 b.h.p.

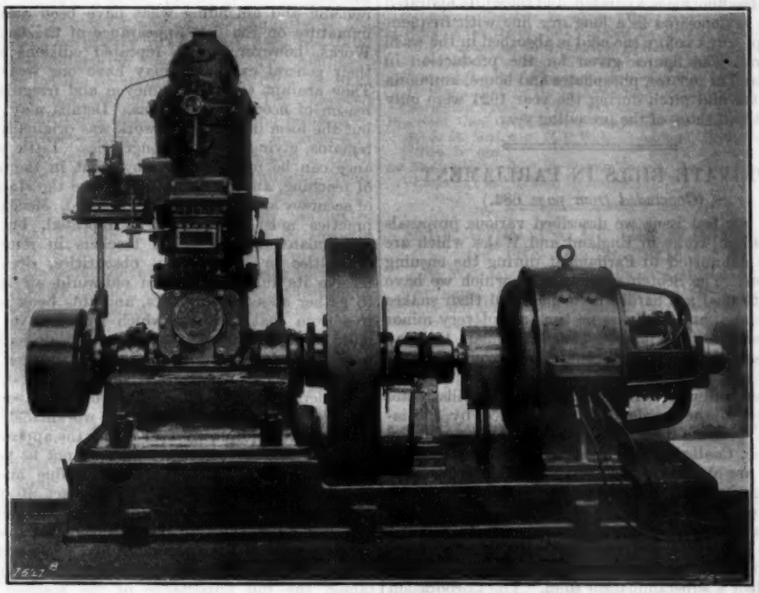


FIG. 3. CRUDE OIL ENGINE AND DYNAMO: MESSRS. ROBEY AND CO., LIMITED, LINCOLN.

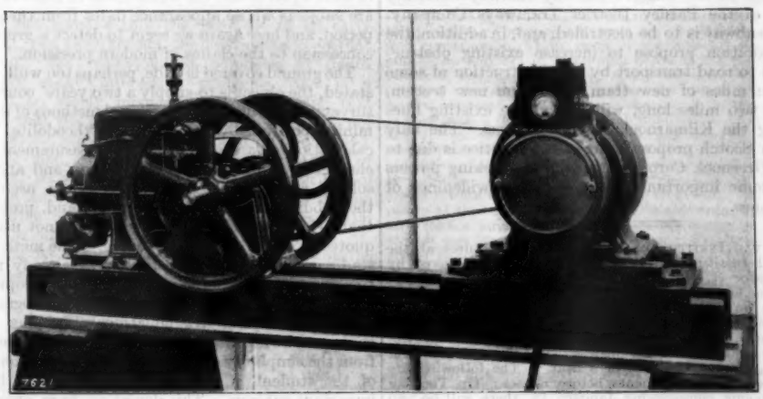


FIG. 4. 2-B.H.P. HOUSE LIGHTING SET: MESSRS. RUSTON AND HORNSBY, LIMITED, LINCOLN.

The number of small petrol-driven electric lighting sets for country houses and isolated establishments shows the popularity of this form of lighting, but the design does not yet seem to have settled down to an accepted type. Vertical and horizontal engines, tank-cooled or hopper-cooled and direct-coupled, or with belt drive to the dynamos, all seem to hold their own, though, no doubt, each finds its peculiar market. Messrs. Ruston and Hornsby, Ltd., of Lincoln, are showing the small belt-driven set illustrated in Fig. 4, annexed. The engine develops 2 b.h.p. at 500 r.p.m., and runs either on petrol or paraffin. The dynamo rated at ⅞ kw. is of the ventilated enclosed type, with commutation poles and ball bearings. Switch gear is arranged in the extension of the commutator shield, which provides for automatic starting and stopping of the machine, and automatic regulation of the lights when the battery is being charged. The whole plant is as simple as it could well be, and of very much better quality than the imported sets which, until the last few years, had the British market very much to themselves. Other exhibitors of small house-lighting sets, or engines for driving them, are Messrs. Petters, Limited, of Yeovil; Armstrong, Whitworth, Limited, of Newcastle; Peter Brotherhood, Limited, of Peterborough; Wallace, Limited, of Glasgow; R. A. Lister and Co., Limited, of Dursley; the Eagle Engineering Company, Limited, of Warwick; Blackstone and Co., Limited, of Stamford; Corbett, Williams and Son, Limited, of Rhuddlan, Flintshire; the Lion Engine Company, Limited, of Pentonville-road, London: Fairbanks, Morse and Co., Limited, of Southwark-street, London, &c. These engines in general are of well-known designs, but a newcomer in the small engine field is the firm of Drummond Brothers, Limited, of Guildford, Surrey, who are exhibiting their "Willing Worker" engine coupled to a saw frame. We illustrate and describe this engine separately, on other pages of this issue.

Among the minor articles of interest is a self-adjusting spanner, exhibited by the Perfect Patent Company, of 195, High-street, Brentford, Middlesex. The head of the spanner contains one fixed and one moving jaw, the latter sliding in guides and having a rack cut on its back. The handle of the spanner is pivoted in the head, the pivoted end being provided with teeth which engage with the rack of the moving jaw. When the spanner is put over a nut, a pull on the handle first closes the jaws until they are stopped by the nut, and then the spanner turns the nut in the ordinary way. The greater the pull on the handle, the more tightly is the nut held. A set of three such spanners will take any size of nut from ¼ in. to ¾ in., and it is, of course, a matter of indifference whether the nuts are of Whitworth, metric or bastard dimensions.

ALKALI WORKS IN 1921.

THE shortness of the fifty-eighth annual report for the year 1921 of the Chief Inspector under the Alkali Works Regulation Act is not an indication of normal conditions and of easy duties. The abridgment is mainly a concession to economy. The work of the inspectors has indeed been more than ordinarily difficult and of special anxiety because many plants have been working under quite abnormal conditions. Managers were, however, always willing to meet the recommendations of the inspectors. Half of the complaints were, as usually, found on investigation to relate to works such as refineries of petroleum and tar oils and to fish manure factories over which the alkali inspectors have no jurisdiction; since chemical manure works

fall under their jurisdiction, the public may be pardoned for not bringing their complaints before the competent authority. The number of registered works had again been decreasing, from 1,403 in 1919 to 1,342 in 1921.

The sulphuric acid manufacture has caused many of the difficulties referred to. Economical working of a large plant at a quarter of its capacity is a very knotty problem, and the sulphur question has demanded particular attention, there and in gas works. Spent iron oxide from gas works has become a common source of sulphur, replacing native sulphur and pyrite; owing to the diminished acid output due to the general depression and to the increased demand for concentrated ammonia, by preference to ammonium sulphate, large stocks of spent oxide have accumulated. Gas works have to pay a high price for sulphuric acid, while their stocks of spent oxide increase, and acid factories equipped solely for the burning of pyrites cannot at will switch over to the use of spent oxide. On the other hand the burning of spent oxide in mechanical furnaces causes dust troubles. To get rid of the dust the Chief Inspector, Dr. T. Lewis Bailey, recommends to place a sump at the bottom of the flue rather than subdivision of the chamber by means of baffles which are apt locally to increase the speed and thus to stir up the settled dust. As regards electric dust deposition there still remains much to be done, we read. In ammonium sulphate works the water seals in the change valves of oxide purifiers are frequently made of an insufficient depth, *e.g.*, of 3½ in.; water is almost invariably used for sealing purposes, but heavier liquids, less liable to freeze in winter, would be preferable.

More serious is the trouble caused by the effluent spent liquors from the distillation of ammoniacal liquors. These liquors vary with their origin, gas works, coke-oven works, iron works, &c., both in bulk and composition, and the relatively small amount of effluent known as the devil liquor (condensed from the saturator waste gases) is more injurious in some respects than the far more bulky direct effluent from the still. But all the effluent may give offence, especially when hot, by reason of the phenoloid and other vapours. The effluents are generally passed through settling and cooling pits before they are allowed to enter the watercourse or sewer; but they remain sufficiently obnoxious to make it sometimes impossible for the works to dispose of their effluents with which local authorities refuse to deal. A considerable portion of the report is hence devoted to an account of the investigation which Mr. S. E. Linder, assistant to the Chief Inspector, has been conducting on the treatment of the effluents. The impurities objected to, and especially the phenoloid bodies, have a high absorbtive power for oxygen, and the effluents hence throw a very undesirable additional duty on the bacteria beds, in which other impurities of the water are to be rendered immune by oxidation. The phenols can be removed by steam distillation; for this purpose the spent liquor is passed down a tower up which a steam injector blows hot fire gases. This treatment does not destroy the colouring of the effluent, however, for which the phenols are likewise responsible. But further experiments conducted on large scale with the aid of Mr. J. W. Buckley, M.Inst.C.E., at the Hornsey Gas Works, show that suitable treatment in one or two scrubbers will sufficiently decolorise and deodorise a bad effluent to render it unobjectionable. This treatment also reduces the thiocyanates and thiosulphates (all the acids are generally combined with calcium in the effluent) for which no direct methods of removal are known; it is noteworthy that the proportions of these latter impurities increase with prolonged storage of the liquors.

The dust trouble above referred to has also come up in rotary cement kilns which still tend to become bigger, although they have already attained lengths of 240 ft.; not much is done so far in the recovery of potash from the dust. We also mentioned chemical manure works. Mr. F. Napier Sutton, one of the inspectors, proposes, for the scrubbing of the gases from such works, to leave some chambers unpacked, but fitted with high-pressure water sprays, and to pack the subsequent two towers with boards on edge, the boards of alternating layers being at right angles to one another. In Scotland, it had been stated in last year's report, some crude phosphate seemed to be more difficult to grind and to contain more than the usual amount of fluoride; anyhow, the wash towers had not been adequate for dealing with the silicon fluoride liberated during the decomposition. This year the inspector for Scotland, Mr. J. W. Young, reports that the somewhat elaborate washing process of Messrs. J. and J. Cunningham, of Leith, has proved entirely successful. In these towers the draught of the exhausting fan is slowed down until it is just sufficient to remove annoyance from the entrance to the mixer, "false air" being kept out; the fluoride is hydrated, and the white hydrated silica is deposited in a long dry flue with frequent abrupt turns before the acid is absorbed in the wash towers. The figures given for the production in Scotland of pyrites, phosphates and bones, ammonia salt, tar and pitch during the year 1921 were only about half those of the preceding year.

PRIVATE BILLS IN PARLIAMENT.

(*Concluded from page* 684.)

In our last issue we described various proposals for public works in England and Wales which are to be submitted to Parliament during the ensuing session. The Scotch schemes with which we have now to deal are hardly more plentiful than snakes in Ireland, and at the same time are of very minor interest or importance. The Caledonian Railway seek sanction for constructing a golf course and an hotel near Gleneagle station, but have no proposals for new railway works. Other railway bills relate merely to the amalgamations required by Parliament. Some new waterworks are proposed by Airdrie, Coalbridge and District Trades Board, but these are of a very insignificant character, viz., the laying of a pipe line from New Monkland to Shotts. The remainder of the bill lodged relates to amendments in the constitution of the board, to defining limits of supply, to land purchases and the like; but powers are taken to erect dwellings and to establish a superannuation fund. The Corporation of Glasgow has lodged a bill to extend their monopoly in local transportation, by acquiring the undertakings of the Glasgow Subway Railway Company and of the Paisley District Tramways Company. The subway is to be electrified, and, in addition, the Corporation propose to increase existing obstructions to road transport by the construction of some seven miles of new tram line. One new section, over two miles long, will extend the existing lines along the Kilmarnock road to Mearns. The only other Scotch proposal that calls for notice is due to the Greenock Corporation, who are seeking powers for some important new streets and widenings of old ones.

Royal Institution.—The Juvenile Lectures at the Royal Institution this Christmas will be delivered by Professor H. H. Turner, whose subject is "Six Steps up the Ladder to the Stars." The first lecture will be given on Thursday, December 28, on "The Distance of the Stars," followed by "The Discovery of the Planet Neptune," "Photographing the Stars," "The Spectroscope and its Revelations," "Two Great Streams of Stars," and "The Size of a Star." The following are the lecture arrangements before Easter: On Tuesday afternoons, commencing January 16, there will be two lectures by Professor F. G. Donnan, on "Semi-Permeable Membranes and Colloid Chemistry," two by Mr. R. D. Oldham, on "Earthquakes," two by Professor A. C. Pearson on "Greek Civilisation and To-day," two by Sir Arthur Shipley on "Life and its Rhythms," and two by Professor C. G. Seligman on "Rainmakers and Divine Kings of the Nile Valley." On Thursday afternoons, the Hon. J. W. Fortescue will give two historical lectures, beginning on January 18, Professor I. M. Heilbron two on "The Photosynthesis of Plant Products," Professor B. Melvill Jones two on "Recent Experiments in Aerial Surveying," and Mr. Theodore Stevens two on "Water Power of the Empire." On Saturday afternoons, commencing January 20, there will be two lectures by Sir Walford Davies on "Speech Rhythm in Vocal Music," two by Mr. J. C. Squire on "Subject in Poetry," and six by Sir Ernest Rutherford on "Atomic Projectiles and their Properties." The first Friday evening discourse will be delivered by Sir James Dewar, on January 19, on "Soap Films as Detectors of Stream Lines, Vortex Motion and Sound." Succeeding discourses will probably be given by Sir Almroth Wright, Mr. C. F. Cross, Sir John Russell, Dr. A. V. Hill, Professor A. S. Eddington, Dr. G. C. Simpson, Dr. M. R. James, Sir Ernest Rutherford, and other gentlemen.

LITERATURE.

A Text-Book of Theodolite Surveying and Levelling for the Use of Students in Engineering, Land, and Mine Surveying. By James Park, Professor of Mining Engineering and Dean of the Faculty of Mining in the University of Otago. Fifth edition. London: Charles Griffin and Co., Limited, 1922. [Price 30*s.* net.]

One approaches the fifth edition of a text book with the respect due to a classic. It has proved its usefulness and evidently challenges recognition. Ample criticism from teachers and pupils will have removed its defects and emphasised its merits. The experience of fifteen years has been devoted to revising and amending what have been amiss or immature on the first appearance of the treatise. Works, however, whose repeated editions attest their general excellence may have one weakness. They are apt to become uneven and irregular by reason of necessary additions. Details may vary, but the form in which the work was originally cast remains, giving rise to incongruities. Little allowance can be made for improvement in the mode of teaching, and attempts to increase the standard of accuracy are liable to be disregarded. Mechanical practice must necessarily be repeated, but the accumulated experience of teachers in removing difficulties or illuminating obscurities, does not receive its full weight. An old-world air is apt to gather about such works, and this book is not free from that blemish, which would have been more noticeable than it is, if the author had not wisely accepted the suggestion of younger surveyors, trained in newer methods and accustomed to modern practice. Innovations brought about by increased ingenuity or improved workmanship in instrumental equipment wear rather the appearance of unwelcome excrescences; they do not fit neatly into the scheme and receive their due amount of attention. For example, the subject of stadia surveying was not introduced till a third edition was demanded, and though the author has given a simple theory of the instrument and explained the method of its use, introducing some convenient tables, the full importance of the method will hardly be apprehended, nor will it be understood how greatly the subject has extended. The theory of least squares and the adjustment of observations are subjects whose appearance dates from the same period, and here again we seem to detect a grudging concession to the claims of modern precision.

The ground covered is wide, perhaps too wide, if as stated, the object is to supply a two years' course in surveying. It includes the general methods of determining position by the chain and theodolite, with calculation of areas from actual measurement. A chapter is introduced on planimetry, and another solving some simple problems that are useful in the subdivision or equipartition of land, problems that belong to plane geometry and are not usually quoted in works on land surveying. The method of stadia measurement of distances, as already mentioned, is left to a later period in the development of the scheme, and nothing is said of photographic measurement and triangulation. Levelling and contour drawing also come late in the book, though from the simplicity of the observations the attention of the student is usually early directed to these important subjects. This deviation from ordinary arrangement is the consequence of inserting a chapter, about one-third of the entire book in length, on the determination of azimuth, time and latitude. Inasmuch as the problems connected with spherical trigonometry divert the attention from the application of the ordinary methods, we cannot but regard the arrangement as unfortunate. Much of the material seems out of place and not quite accurate in character. For example, we cannot imagine any problem coming before a student in surveying, in which he would be assisted by the loose information given here connected with the Precession of the Equinoxes.

The undesirability of entering into such niceties is shown by the lax definition of the sidereal day, stated to be the interval between two successive transits of a star crossing the same meridian. This is not accurate: it should be, the interval of time between two successive transits of the First Point of Aries, and the slight difference could

easily have been overlooked if the Precession of the Equinoxes had not been insisted on so prominently. The equation of time, too, is not correctly described, and many students must have found the explanation perplexing. After defining the equation of time as the difference in time between the transit of the Mean Sun and the Apparent Sun, we are told that at the equinoxes and solstices, the apparent Sun and the mean Sun coincide, and at these times of the year the equation of time vanishes. Yet on the same page, the dates for the disappearance of the equation of time are correctly given and these by no means coincide with the times of equinox and solstice. The curve showing the summation of the effects due to the effects of the eccentricity of the Earth's orbit and of the obliquity of the ecliptic is accurately drawn, but does not tally with the letterpress (page 238). The quaintest example for the determination of latitude we have ever seen appears on page 332. The observed meridian altitudes of Polaris, above and below pole, are given respectively as 60 deg. 17 minutes and 29 deg. 30 minutes. This gives Polaris a north declination of about 74 deg. 36 minutes. This incongruity is the more remarkable, as later the method of determining latitude by an extra meridional altitude of the Polar Star is correctly given.

The subdivision devoted to engineering surveying is not clearly defined, several chapters throughout the book being devoted to such subjects as setting out road angles, railway curves, the construction of canals, &c. These are all practical subjects generally well treated, and to which more space might have been devoted with advantage. We notice that the method of setting out transition curves adopted by the Public Works Department, New Zealand, has been supplied by Messrs. Holmes and Furkert.

To mining engineering a separate section is devoted, and it is certainly one of the best in the book, giving evidence of long and close experience. The difficulties to be encountered in carrying on linear and angular measurement are fully recognised and ably explained. The treatment is thoroughly practical and is of that character which an experienced engineer would be more disposed to give to a trained expert in surface work, than to a novice. Most of the problems discussed here would not come within the province of an early student, but they are not the less welcome on that account. The behaviour of boreholes at depth presents many interesting problems, and is a subject so rarely mentioned in elementary text books, that the possible amount of deviation is not appreciated, nor its method of detection understood. We are glad, therefore, to have the methods of Marriott so well described, and the suggestions of Kitchin concerning the origin of departure from verticality are well worth studying. Some later information might have been quoted since experience is being rapidly acquired, and working hypotheses are being subject to critical examination.

BOOKS RECEIVED.

The Principles of Relativity with Applications to Physical Science. By A. N. WHITEHEAD, Sc.D., F.R.S. Cambridge: University Press. [Price 10*s.* 6*d.* net.]

Institution of Engineers and Shipbuilders in Scotland; Manœuvring of Ships. Part I. *Unbalanced Rudders of Single-Screw Ships.* By J. S BAKER, O.B.E., and G. H. BOTTOMLEY. Glasgow: Published by the Institution.

Hydro-Electric Engineering. Vol. II. *Electrical.* Edited by Professor A. H. GIBSON, D.Sc., M.Inst.C.E., M.I.Mech.E. London: Blackie and Son, Limited. [Price 30*s.* net.]

Wireless; Popular and Concise. By Lieutenant-Colonel C. G. CHETWODE CRAWLEY, R.M.A., M.I.E.E. London: Hutchinson and Co. [Price 1*s.* 6*d.* net.]

The Triumph of the Tramp Ship. By ARCHIBALD HURD. London: Constable and Co., Limited. [Price 7*s.* 6*d.* net.]

How to Form a Company. An Explanation of the Documents Filed on Incorporation and the Principal Statutory Requirements affecting Companies. By HERBERT W. JORDON. Fifteenth edition. London: Jordan and Sons, Limited. [Price 1*s.* 6*d.* net.]

Technische Schwingungslehre. By Dipl. Ing. Dr. WILHELM HORT. Berlin: Julius Springer. [Price 24*s.*]

The Institution of Production Engineers. Proceedings, Session 1921–22. London: Published by the Institution.

The Theory of Allotropy. By A. SMITS, Ph.D. Translated from the German by J. SMEATH THOMAS, D.Sc. London: Longmans, Green and Co. [Price 21*s.* net.]

Theoretical Naval Architecture. By EDWARD L. ATTWOOD, O.B.E., M.I.N.A. London: Longmans, Green and Co. [Price 12*s.* 6*d.* net.]

Motor Headlights. Reprinted from the Transactions of the Optical Society. Vol. XXIII, No. 4, 1921–22. London: The Optical Society. [Price 2*s.* 6*d.* net.]

Hydraulic Diagrams for the Discharge of Conduits and Canals, Based upon the Formula of Ganguillet and Kutter. By THEODORE HORTON, M.Am.Soc.C.E., and the late CHAS. H. SWAN. Third edition, revised and enlarged. New York and London: McGraw-Hill Book Company, Inc. [Price 5*s.* net.]

The Sanitation of Bath Houses. By WM. PAUL GERHARD. New York: The William T. Comstock Company. [Price 60 cents.]

The Law relating to Electrical Energy in India. Being the India Electricity Act, 1910. *Act IX of* 1910. By J. W. MEARES, C.I.E., F.R.A.S., M.Inst.C.E., M.I.E.E. Second edition, revised throughout. Calcutta: Thacker, Spink and Co. [Price 24*s.*]

History of the Great War. Based on Official Documents. By Direction of the Historical Section of the Committee of Imperial Defence. The War in the Air. Being the Story of the Part Played in the Great War by the Royal Air Force. Vol. I. By WALTER RAYLEIGH. Oxford: The Clarendon Press. [Price 21*s.* net.]

Practical Civil Engineering Simplified for the Far East. By J. R. MCLEOD, M.P.W.I. London: Cecil Palmer. [Price 7*s.* net.]

La Radiotéléphonie. By CARLO TOCHÉ. Paris: Gauthier Villars et Cie. [Price 10 francs.]

STRENGTHENING OF THE FLOOR, &c., OF THE FORTH BRIDGE.*

By WILLIAM ALEXANDER FRASER, M.Inst.C.E.

THE paper describes the renewal of the inner rail-troughs and the buckled plating of the floor of the bridge, the strengthening of the cross-transoms of the internal viaducts, and the provision of additional cross bracing between the main girders of the approach spans. The rails which form the up and down lines on the bridge are carried on timber waybeams, laid in four continuous steel troughs. The two outer troughs form the top boom of the main girders of both the north and south approach spans and the internal viaducts. The two inner rail-troughs, on the other hand, are carried on cross-transoms which span between, and connect to, the side plates of the top booms of these girders. From bay 4 of the cantilevers, where the internal viaduct terminates, to the ends of the cantilevers and across the central spans, the four troughs are carried on cross-transoms spanning between the bottom booms of the cantilevers and the main girders of the central spans.

The section of the old troughs was uniform throughout the bridge, with the exception of the troughs over the cantilever ends and central spans, which had a heavier section to suit the wider spacing of the transoms. The troughs were side-stiffened by sloped supports riveted to the troughs and the cross-transoms. Buckled plating, with the buckle convex, closed the floor between the troughs, the plates being riveted to the lower flanges of the troughs. The cross-transoms are of ordinary plate-web construction, 12 in. deep in the internal viaducts and 24 in. and 47½ in. maximum depth in the approach viaducts and central girder spans respectively. The internal viaduct transoms, unlike the others, have a central support. The maximum spacing of the transoms ranged from 7 ft. in the approach viaducts to 15 ft. and 22½ ft. in the internal viaducts and central spans respectively.

In the course of renewing the timber waybeams in 1906, it was discovered that the bottom plates of the inner troughs were fractured between the rivet holes in many places at the support of the trough on the cross-transom, and that a large number of the rivets connecting the trough and transom had worked loose. The horizontal rivets in the cross-transom connecting the top angle and web immediately beneath the inner troughs had also worked loose through lack of rigidity in the transom, these rivets having on previous occasions given trouble. The defects were attributed previously to (*a*) the heavier loads passing over the floor of the bridge, and (*b*) the lack of rigidity of the inner troughs as compared with the outer troughs, the destructive effect being accentuated by water and grit discharged from the inside of the troughs. In 1890, when the bridge was opened for traffic, the weight of a locomotive was 77½ tons, with a maximum axle weight of 15½ tons, whereas to-day these weights amount to 119¼ tons and 20 tons respectively.

Before the new waybeams were placed, all the loose rivets were cut out, the fractured bottom plates were reinforced with covers placed inside the troughs, and new rivets were inserted. In 1908, while the renewal of the timber waybeams was still in progress, it was evident that the repairs were not likely to prove satisfactory, as a large number of the new rivets had again worked loose. In 1909 it was decided, as an experimental measure, to insert an additional cross-transom between the existing transoms at bays 3 and 4 of the cantilevers, so as to give additional support to the lighter inner rail-troughs. The provision of these transoms did not, however, provide a remedy for the deterioration at the bearings, which, by 1911, had developed to such an extent as to necessitate consideration of further remedial measures. It was decided, therefore, to renew the inner rail troughs and buckled plating on the approach and internal viaducts, to strengthen and stiffen the cross-transoms of the internal viaducts, and at the same time to provide additional cross-bracing between the main girders of the approach spans so as to brace each panel-point, the existing bracing being arranged at alternate panel points only.

The new troughs are constructed of three steel channels, 17 in. deep, which had to be specially rolled, and which give a very stiff section with a minimum amount of riveting—a matter of considerable importance in a floor of this type. To prevent the percolation of water from the inside of the troughs, a close rivet patch was adopted, the edges of the bottom channel being caulked. The stresses in the new troughs were calculated on the basis of the latest axle-loading, assuming the troughs to be continuous, and adopting a modified unit stress of 4 tons per square inch. The section-modulus of the original troughs for spans up to 15 ft. was 100 units as against 137 units in the new troughs, and for the larger spans 184 units as against 197 units. The old type of sloped lateral support, the riveting of which gave considerable trouble, was discarded in favour of a flat right-angled support which, after experiment, was found to be sufficient and which enabled an efficient connection to be made between the trough and transom without the necessity of riveting the trough and transom directly. This was important in view of the trouble experienced with the rivets connecting the old troughs to the transoms, and was a decided improvement from a maintenance point of view, as in future repairs could be carried out without disturbing the permanent way, which was impossible under the old arrangement.

The strengthening of the internal viaduct transoms and the reduction of shear on the web rivets have been effected by increasing the depth of the transoms by means of additional angles riveted to the lower flange and by providing heavy bosom plates on each side of the web immediately below the inner troughs. The section-modulus of the original transom was 35·3 units, while that of the stiffened transom is 87·4 units.

The new buckled plates between the troughs are riveted to the bottom flange of the troughs as before, but the curve of the buckle is reversed. This alteration was made with the object of throwing all debris and surface water to the centre of the plates, instead of to the sides as formerly, difficulty having been experienced in keeping the junction of the floor-plate and the bottom flange of the trough in a satisfactory condition, owing to lodgment of debris and water there.

The work was carried out by means of timber platforms hung from the main girders. The renewal of the troughs and work in connection therewith was done on Sundays, the remainder of the work, which did not interfere with the running lines, being carried out in stages during the week. On Sundays it was necessary to retain one line for traffic, and for this purpose a fully-equipped electric tablet system of single-line working was installed. The up and down lines were closed on alternate Sundays, the troughs in both lines for one section being completed before the work on another section was commenced. An extensive system of temporary horizontal bracing was adopted so that the old floor plates could be cut out and the rivets could be removed during the week, without materially impairing the rigidity of the viaduct under traffic conditions.

The work, the greater part of which was carried out under war conditions, was commenced in May, 1914, and was completed in September, 1920, the number of troughs laid being 340, occupying 145 Sundays.

The approximate weight of old steelwork removed from the bridge was 2,400 tons, and the weight of new steelwork used was 3,312 tons. The net cost of the work, exclusive of the cost of the work in lifting and replacing the timber waybeams, rails, &c., was 147,299*l.* The contractors for the renewal of the steelwork were Messrs. Sir William Arrol and Co.

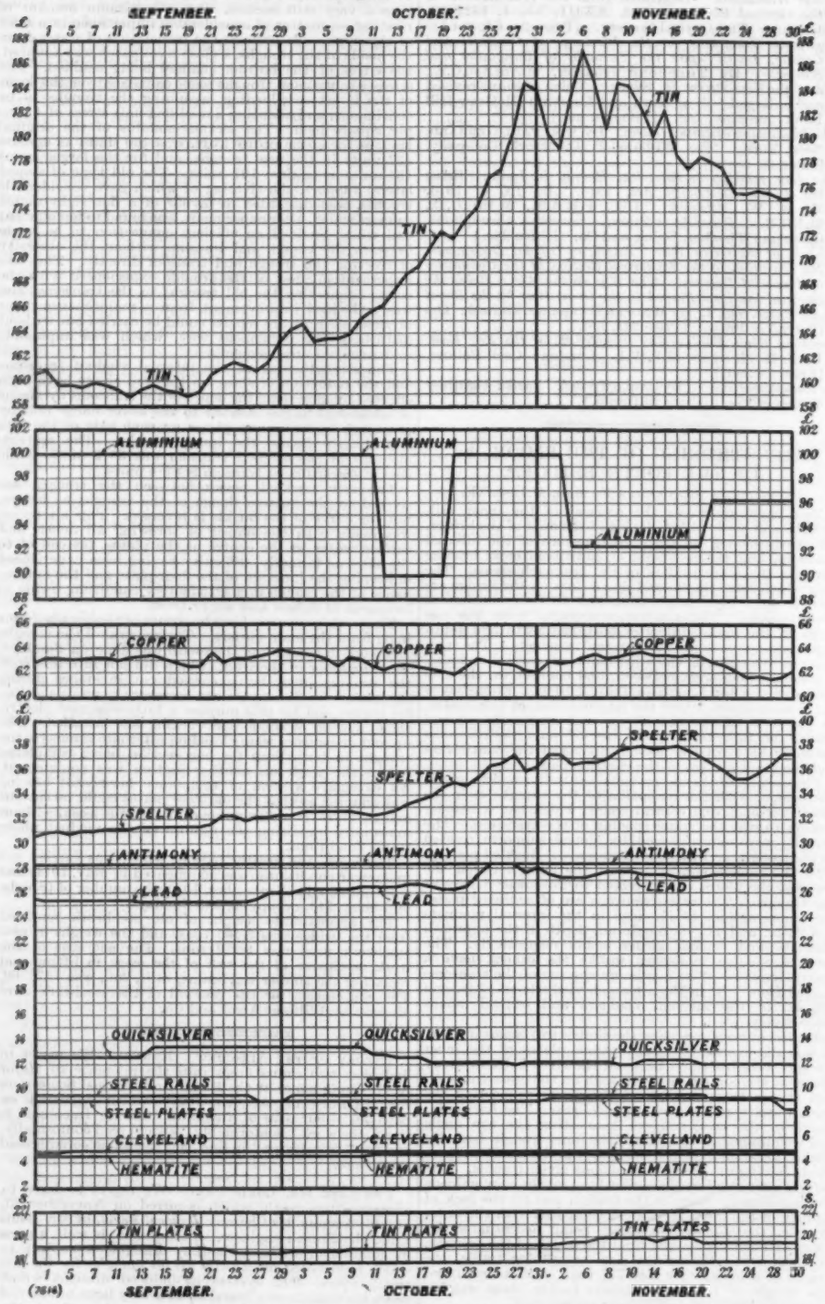
* Abstract of a paper read before the Institution of Civil Engineers, on Tuesday, December 5, 1922.

THEORY OF THE AIRSCREW: ERRATA.—We regret to find that two errors crept into the reference to Major A. R. Low's paper at the Royal Aeronautical Society on the "Theory of the Airscrew," which appeared on page 593 of our issue of November 10 last. In column 2, line 8, the word "conformably" should read conformally, and for "spiral cone" in line 58 of the same column read spiral core.

THE LATE MR. LOUIS PRAT.—We regret to have to announce the death, which occurred on November 20, at 146, Avenue des Champs Elysées, Paris, of Mr. Louis Prat, the French engineer, whose name is well known in connection with mechanical draught, a subject to which he devoted practically all his energies for the last thirty years. The system of induced draught which bears his name is now installed at a very large number of works, factories and power stations throughout the world. At the time of his death, Mr. Prat was managing director of the Société des Cheminées Louis Prat, a company which was constituted a few years ago to operate the Prat patents. The earliest practical example of Mr. Prat's system dates from 1892, when he had occasion to investigate the problem of evacuating acid vapours arising from the manufacture of nitrate cotton in one of the French national powder factories. The upkeep of the fans dealing with the corrosive gases had been very heavy, and Mr. Prat was led to study the question of drawing these off by an indirect method. The first application of his system comprised several blowers working in parallel, and the essential feature, namely, the diffuser or expanding portion of the chimney. It is interesting to add that this first installation is still in operation. Further investigations during the years 1892 to 1895 resulted in Mr. Prat's development of the low-pressure ejector, which he subsequently applied to various industrial uses, and chiefly to mechanical draught for boiler installations. Mr. Prat was 71 years of age and had been in failing health for many months. He was a member of the Société des Ingénieurs, Civils de France, having joined that institution in 1890.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN THE PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



Note.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for the East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

Fat Hardening.—A recent paper by Dr. W. Normann, one of the pioneers of the fat-hardening industry, contains statistical information about this subject, which was discussed before the British Association at Hull (page 472, *ante*). The 24 fat-hardening works of 1914 have increased to about 90, but a good many of these works are idle or not working to full capacity. The 18 European works of 1914 produced 230,000 tons of hard fat annually, and the industry became very important to Germany during the war, when very inferior and rancid rape oil and whale oil had to be turned into edible fats. The 15 works of the United States were credited with an annual productive capacity of 142,000 tons of hardened fat, but the 1921 figure was only 98,071 tons. Fish oils are seldom converted into table oils there, yet the increased demand for whale oil is hastening the extermination of the whale, though in normal times vegetable oils ought to suffice to satisfy the world's needs.

THE ELVERSON OSCILLOSCOPE.

The study of faulty action in a mechanism operating at high speed has always proved of considerable difficulty. The eye cannot follow the actions, and although noise may give a clue to what is wrong deductions cannot always be made with certainty. To make it possible to examine parts in movement, Mr. Elverson, of Messrs. Herbert Kennedy and Co., Limited, of 47, Victoria-street, Westminster, has introduced an instrument by means of which the motion of a mechanism can be made to appear slowed down or stopped, while the normal speed of operating is maintained. We have had the opportunity of witnessing interesting demonstrations with this instrument in studying the movements of the many mechanisms in a sewing machine. The essential parts of the instrument are illustrated in Figs. 1 to 5, herewith.

The principle of its operation can be understood if the apparent positions of the seconds-hand of a watch

Fig. 1.

are viewed when illuminated by flashes of light at intervals. If the watch face is illuminated by a flash of light every minute, the seconds-hand would appear to the observer to be stationary. If the light flashes are made more frequent, the seconds-hand would appear to rotate counter-clockwise but slowly, but if made less frequent the rotation would be in the common direction but also at a slow rate. Similar actions to these comparatively slow ones are used in the oscilloscope but at speeds that are more suitable for the examination of the fastest moving parts of any mechanism.

The stroboscope has been successfully applied to the study of movements that are periodic, both in the workshop and in the laboratory. In this instrument the light flashes are obtained by the rotation of shutters or screens with holes in them through which the light rays pass at the predetermined intervals. The great disadvantage of the operation of the mechanical screen arrangement is the limited speeds at which satisfactory working can be obtained.

In the oscilloscope no mechanical screens are in use as the light is put on and off for the purpose of obtaining the flash. An ordinary incandescent lamp cannot be used for this purpose because of the time taken to raise the filament to incandescence and cool it down

again. Lamps in which electric discharges are passed through gases have an exceedingly short time-factor, and it is one of this type (Fig. 1), with a bulb containing neon which is used in the oscilloscope. If such a lamp receives its supply one thousand times a minute, any mechanism working at that speed examined with the light from the lamp would appear stationary.

Some device is necessary to ensure that the timing of the illumination of the lamp will correspond with that of the mechanism if it is to be studied when apparently stationary, or to give the correct relationship between the two speeds, if the mechanism is to be studied when apparently running slowly. The oscilloscope has a mechanism for this purpose which consists of a gear box, driven from the machine under study, and a pair of interrupters for the lamp supply. The current is taken from a secondary battery and is passed through the primary winding of an induction coil after going through the interrupter. On the high pressure side of the coil the supply for the neon lamp is obtained at a pressure of about 850 volts.

This contact breaker is shown in detail in Figs. 2 to 4, annexed. Its operation is accomplished by the upward movement of the spring-held cylindrical piece marked A, which receives its motion from a cam through the projecting rounded end. The motion so obtained is communicated to the long flat spring and lifts it from its normal position in contact with the adjustable stud, marked B, interrupting the circuit. The cam which is situated inside the gear box has upon it four projections situated on two diameters at right angles to one another. These parts of the cam are continued to different distances from the centre of rotation and thus provide one, two or four actions during each revolution. The movement necessary to alter the number of cam actions for each cycle is given to the whole of the interrupter gear which can be slipped into the different required positions while the apparatus is working. The use of two or four contacts during a revolution makes it possible to study vibration actions and determine the total range of the movement caused by the vibration. The position of the interrupters on the gear box is seen in Fig. 5, where they are depicted on the horizontal diameter. This interrupter gear forms the subject of an application for a patent by Mr. Elverson.

The gears are situated inside the gear box which has upon its outer edge a protractor which is used in the determination of the magnitude of torsion actions. The twist on a shaft, when transmitting power, is obtained by noting the angles at which two marks, which are in line with each other and with the shaft when it is stationary, appear under the oscilloscope lamp when running.

The gear box is provided with two distinct gears, the one giving the exact speed of the mechanism to the interrupter and the other giving a speed one-hundredth

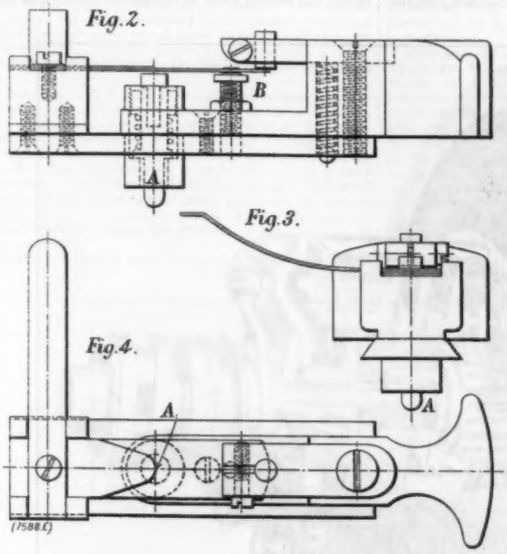


Fig. 2.

Fig. 3.

Fig. 4.

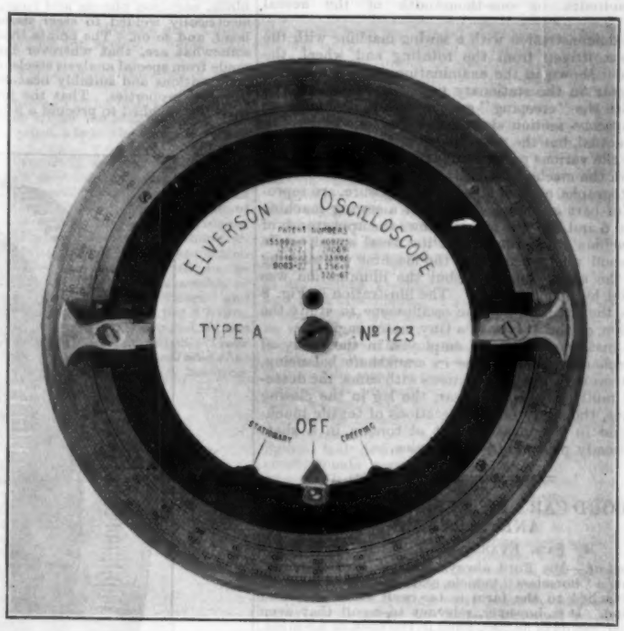


FIG. 5.

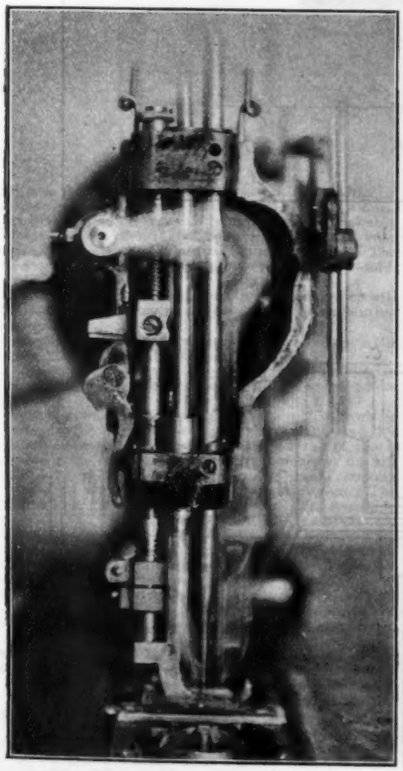


FIG. 6.

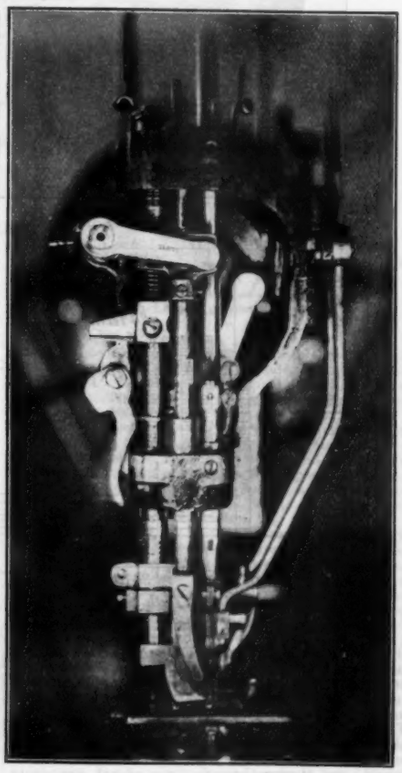


FIG. 7.

FIG. 8.

or one-thousandth less. The first gear provides the illumination requisite for "stationary" examination, but the second gives a relative difference of speed between mechanism and illumination which results in the production of an apparent motion at a rate of one-hundredth or one-thousandth of the actual value.

In a demonstration with a sewing machine with the gear box driven from the rotating end wheel, the definition shown in the examination, with the instrument gear on the stationary position, was very good, and with the "creeping" gear in action, not only was the apparent motion slowed down to one-hundredth of the actual, but the play, bouncing actions and backlash in the various parts were markedly shown and the faults in the mechanism easily traced.

Photographs, each of 90 seconds exposure, are reproduced of part of the mechanism of a sewing machine in Figs. 6 and 7. The former shows the appearance of the machine when running at its usual speed, while the second was taken when the machine was running under the same conditions, but the illumination was provided by the neon lamp. The illustration in Fig. 8 depicts the fitting up of the oscilloscope to study the operation of the valves of a Guy motor engine.

The instrument can be employed in the study of any mechanism, and its use in crankshaft balancing, the detection of bouncing actions with cams, the detection of faulty wheels in a gear, the lag in the closing of valves, the study of the operations of textile machinery and in the measurement of torsion in a shaft have already proved of great service.

THE FORD CAR: ITS DESIGN, PRODUCTION AND SERVICE.*

By Sam. Evans, M.Sc., A.I.M.M.

Historical.—Mr. Ford always had the idea of manufacturing a "horseless" vehicle, and the story of the little shed attached to the farm is too well known to need repetition. It is, however, relevant to recall that even in the earliest days he had, fixed in the back of his mind, the idea of a "Universal" car, but found it impossible to put into execution owing to the fact that in those days the only advertising possible was by means of a "speed" car to compete on the track. Thus the present position is only the realisation of Mr. Ford's original idea (or rather the "partial" realisation of it).

Prior to 1903 a certain number of cars were manufactured and sold, but continuous manufacturing was not developed until the formation, in 1903–4, of the Ford Motor Company. In this, the first year of operation, the company had a factory area of 0·28 acres, employed 311 hands, had one branch office, and built 1,708 cars. In 1907–8 the factory covered 2·45 acres, employed 2,000 men, had 14 branches, and built 6,181 cars. The cars were runabouts (model R), selling for 700 dols., and Roadsters (model S), selling at 750 dols. In 1908 the more or less accidental discovery of vanadium enabled Mr. Ford to build a standard chassis on which were mounted the following body types: Roadster at 825 dols., Tourer at 850 dols., Coupé and Landaulet at 950 dols., and Town Car at 1,000 dols. This was the well-known model T, and 10,607 cars were sold.

In 1909 the company was so well established that Mr. Ford felt justified in voicing the policy embodying his original idea, which had only been strengthened by his manufacturing experience, viz., a universal car. Naturally the salesmen opposed the idea, and favoured the introduction of special lines, and the introduction of new features to catch the public eye, but Mr. Ford believed that they were neglecting the 95 per cent. possible buyers with no fixed ideas about their car needs to go after the 5 per cent. probable buyers with very special ideas as to the kind of car they wanted. Thus it was announced that there would in future be one standard chassis, and that "any customer could have his car painted any colour he liked providing he chose black." The salesmen urged that the lowering of price would lower the sales, and that cheapness meant poor quality, for in those days the motor car was still regarded as a luxury. So convinced was Mr. Ford in the soundness of this policy that he bought 60 acres of land for a new factory at Highland Park, Michigan, and the slogan born of this venture was "how soon will Ford bust?" However, to recoup part of this expenditure the prices were raised slightly, and the company sold 18,664 cars.

In 1910–11, with the new manufacturing facilities, the Tourer price was cut from 950 dols. to 780 dols., and the company sold 34,528 cars. The factory at this stage occupied 32 acres.

Since that date there has been a steady reduction in selling price against increases in the cost of labour and raw materials.

The phenomenal progress made may be gathered from the figures below:—

Year 1908: 2·65 acres 1,908 men 6,000 cars.
Year 1911: 32·0 acres 4,110 men, 25,000 cars.
Present day: 300 acres, 35,000 men, 1,500,000 cars.

The English branch, situated at Manchester, has increased in a similar manner since its inception in 1911, and the policy has been mainly directed from the home plant. At the present time the plant, by the employment of 2,000 men, is capable of an output of over 1,000 cars weekly, with a factory area of 12 acres.

Design.—Regarding the design of the Ford car I have not a great deal to say. There are no very novel features, i.e., features which radically differ from the present-day "best practice." The engine has a cast-iron cylinder block, cast-iron pistons and rings, cast-iron valve heads electrically welded to steel stems, detachable cylinder head, and so on. The points that might be emphasised somewhat are, that wherever bolts are used they are made from special analysis steels of two or three different compositions and suitably heat-treated to give the best physical properties. That the pistons and rods are all carefully weighed to procure a properly-balanced engine, and that the white metal used is of a much more uniform and better composition than is generally employed for petrol engine bearings of a similar kind. The water system shown is not one that requires any special comment.

The transmission illustrated in Fig. 1, on this page, is probably the most interesting portion of the Ford car. The power is transmitted from the crankshaft to the flywheel, and thence through three planet compound gears known as triple gears, which mesh continually with three driving gears fixed to the three transmission drums. Thus the speed changes are obtained without any demeshing and remeshing of gears. The various changes are obtained by the depression and release of various pedals (three in number), which act by tightening bands round the transmission drums, thus fixing them in position, the attached gear then acting as a "sun" gear round which the planet gears revolve, thereby transmitting the motion to the driven gear, and thence to the driving plate and drive shaft. A reference to the sketch (Fig. 2) will make this abundantly clear. The three transmission drums with their attached gears are shown at A, B and C; the gears meshing with the three gears of the "triple gear" F revolving on the pin G attached to the flywheel. The brake drum A is attached to the driving plate assembly D, and also contains the clutch plates, connecting the drum A with the disc drum H, which is keyed to the transmission shaft. The operation of the transmission is that the drums are fixed as required, to form a stationary gear for the planets to revolve around whilst transmitting their motion to the following gears.

For the reverse, the depression of the reverse pedal causes the reverse band to tighten on the reverse drum C,

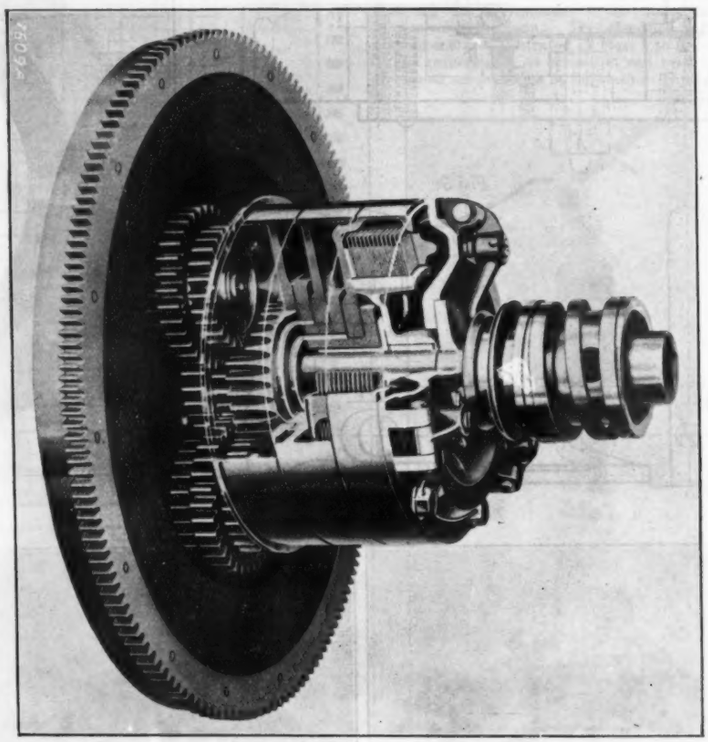
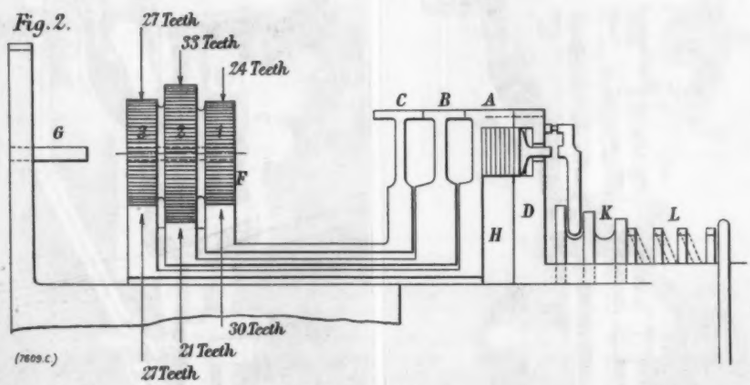


Fig. 1.



which becomes stationary. The attached gear then remains fixed and the triple gears rotate round it and drive the other gears.

From the general formula for epicyclic gears:

$$e = \frac{n \pm a}{m \pm a}$$

e = Value considered as ordinary train,
n, m and a = Revolutions of last and first wheels, and arm,

we get that since the first wheel C is travelling in same direction as last wheel A, that e is positive, i.e., considering as an ordinary train, and since the first wheel C is fixed, then a is negative. Consequently:

$$+\frac{30}{24} \times \frac{27}{27} = \frac{n - 1}{0 - 1}$$

$n = -\frac{1}{4}$ Transmitted to driveshaft.

Slow speed:

* Abstract of paper read before the West Bromwich Engineering Society, on Friday, November 17, 1922.

$$+\frac{21}{33}\times\frac{27}{27}=\frac{n-1}{0-1}$$

Drum B fixed by band.

$$n=+\frac{12}{33}$$

Transmitted to driveshaft.

High speed: The pedal is allowed to go free and the clutch spring L acting on the clutch shift K depresses three clutch fingers, which tighten the clutch plates through a clutch ring. This locks the whole gearing of the transmission solid so that there is a straight through drive from flywheel to driveshaft. Of course, all the above ratios are modified by the crown wheel and pinion of the rear axle, which have 40 teeth and 11 teeth respectively.

The drum A is acted on by the brake band of the brake pedal.

The ton truck rear axle is simply an ordinary worm drive with the differential mounted inside the worm wheel. The front spindle or stub axle is of the usual construction. The location of the roller bearings, front axle, spindle body forging, and felt washer is shown in Fig. 3. The transmission is thus seen to be a very compact unit, and its flexibility is undoubted. The main point regarding design is that there has been no radical alteration since the commencement, and no changes are introduced which cannot be applied to the car as at present extant.

Production.—Briefly stated, the secret of large production is intelligent direction of power and machinery, and the results obtained are so unusual that they must be experienced to be thoroughly appreciated. Probably the best manner of bringing their significance to your minds is to quote certain actual figures obtained. The methods adopted to increase production are threefold, and are:—

1. The tools and men are placed in positions which will eliminate as much travel as possible of parts during manufacture.

2. Automatic work carriers are provided to move the part away and replace it with another part.

3. Automatic assembly lines are provided with auxiliary lines to deliver the assembly units where required.

Thus a man is practically stationary, his work is brought to him and carried away from him, and his parts are delivered at his feet. The main result of this is that not only are all unnecessary movements on the man's part eliminated, but the amount of actual thinking he has to do is reduced to an absolute minimum. The following examples speak for themselves. The assembly line principle was first tried in 1913, and we are told it was imported from the Chicago beef-packing factories. The flywheel magneto was the subject of the first trial (a small assembly being advisable for a start).

Originally one man completed one assembly and did 35 to 40 pieces in 9 hours, *i.e.*, or about 20 minutes per assembly. The assembly was divided into 29 operations, and this cut the time to 13 minutes. Then the "line" was raised 8 in. in 1914 to cut out stooping, and this reduced the time to 7 minutes. Further experiments as to speed of line travel, varying from 10 in. per minute to 18 in. per minute, and finally fixing on 44 in. per minute, cut the time to 5 minutes.

In the English factory this assembly is an auxiliary to the main engine assembly, the final position being just at that point in the engine assembly where it is required to fit it to the engine.

The motor assembly is divided into 84 operations, and the motors are assembled at thrice the original speed. The chassis assembly time progress was as follow:—

Originally stationary, and took 12½ hours. Rope and windlass with a line 250 ft. long, six assemblers, and piles of parts down the line. Time taking 5 hours 50 minutes. 1914 raised the conveyor to "man-high," and had two lines to suit different squads, viz., 20¾ in. and 24½ in. Time taken 1 hour 33 minutes.

English Factory.—A reference to the diagram, Fig. 4, will give some idea of the co-ordination of these various assemblies in the Manchester plant. A rough outline of the main operations in sequence is as follows: Magneto, triple gear bush pressed in and reamed. Transmission drums fitted together. Driven gear fitted and reamed on floating reamer. Transmission shaft riveted to flywheel, triple gear pins fitted, transmission drums and triple gears fitted to flywheel. Disc drum pressed on and keyed. Clutch plates. Push ring. Driving plate, assembly screwed on. Test run. Magnets on. Clutch shift. Clutch spring. Test for spring. Joins main engine assembly.

The outline diagram, Fig. 4, shows the lines of these assemblies.

Every piece of work moves in slides either overhead or otherwise, from the point where the last operation was performed on it, to the point where the next operation is performed.

Trucking.—The only trucking is that of materials which are taken in small electrically-driven trucks, or small, short wheel-base chassis pulling trailers which are able to get into any aisle where needed. Stacks of parts are piled neatly on wooden trestle platforms placed near the machines, and lifted by lever trolleys when full. All trucking is under the control of a separate transportation department. Nothing is too small to be standardised, *e.g.*, connecting rod and piston assembly or piston-rod assembly. Originally, two benches and 28 men, output was 175 assemblies per man per 9 hours. The operations are: Push pin out, oil it, slip rod in, put pin back, tighten one screw, and slacken another. These operations when analysed by the stop watch, showed that 4 hours in 9 hours were spent in walking, bending, shifting of feet, &c. It was divided into three divisions, with a slide bench, and 3 men per side, and an inspector at the end. Each man performed one-third of the operations. The men were reduced to 14, and they turned out 5,000 in 8 hours.

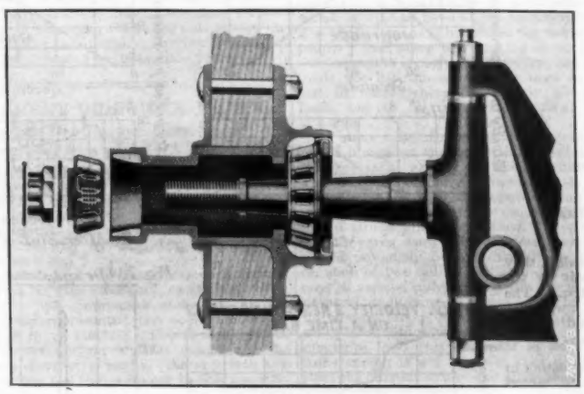
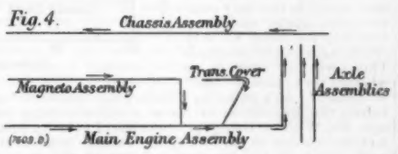


FIG. 3.



Radiator Assembly.—There are two special-purpose machines here, viz., a tube rolling machine which rolls tubes at the rate of 2 ft. per second, and a fin-making machine which turns and flattens the edges, cuts the holes and burrs them, and cuts off to length, and stacks them, at the rate of 2,500 per hour. These are fairly representative methods of production.

Shipping.—Even in shipping, on account of the enormous amount of freight the home plant deals with, attempts have been made to economise work and space. Thus each size of case used is designed with internal supports and cross-pieces to take certain parts. Loose packing material is never used; all interstitial space being filled according to definite plan with smaller parts.

The parts are stacked in tiers to eliminate internal nailing, and in fact packing is treated scientifically.

Service.—The keynote of this department is that Mr. Ford believed at the outset that it should be possible to make parts so cheaply that it would be more economical to buy new than repair old ones. The car should be so simple that no one could fail to understand it. Spares could be carried in ironmongers' shops like nails, screws, &c. Later the appearance of spurious parts, which are necessarily inferior, made it advisable to concentrate our service system in the hands of "authorised Ford dealers," who were made to regard themselves as a direct part of the organisation. The Manchester plant has about 700 of such dealers, situated mostly in separate towns or villages, except where two or three are necessary to take care of a large city.

If any Ford owner requires a repair, he can requisition the services of the nearest Ford dealer, who will replace the damaged part from stock in the course of a few hours at most, and maybe a few minutes. He should also in most cases be able to define whether the damaged part is genuine Ford or spurious, and if he cannot, he is instructed to forward same to factory for examination. The prices of spares are very reasonable, and the parts themselves are so standardised, and the dealers so specialised in Ford work by reason of handling nothing else that the labour charges are reduced to a minimum.

Most of our dealers by their own initiative and the impetus given to labour-saving devices by their visits to the works have had special machines installed for doing special work, *e.g.*, burning in, reboring, &c.

If any Ford owner is dissatisfied with any car part he takes the matter up with the dealer in his district, and if there is any controversy the factory will adjudicate on the case. The service policy of the company aims to create a satisfied owner, and whilst that is impossible to the extent of 100 per cent. in any country, I venture to say that in our own case we are immeasurably nearer to that standard than any other car manufacturer.

Technical.—The technical service of the company is also very complete and is responsible for the maintenance of the quality of the car and the spares carried by or issued to authorised dealers. Every car part, of which there are over 5,000, is represented by one or more blue prints. These prints specify the highest and lowest limits allowed in dimensions, mechanical properties, chemical analysis and heat treatments. The only latitude allowed to a manufacturer is in his method of manufacture, so long as he arrives at the correct dimensions, but even in this case any specialised methods developed by the Ford Company are always at his service if he cares to see them. The result is obvious. If by any means we can increase his production or decrease his manufacturing cost, we reap the benefit on a lower quotation. As regards the chemical analyses and heat treatments, the Ford Company will not allow any variation from the figures laid down, except in very special cases. All consignments arrive at the "receiving department," who check them for weight, quantity, &c., as required. They are then passed on to the inspection department, whose work is very largely standardised. By the provision of master jigs, "go" and "not go" gauges, &c., the parts are either inspected piecemeal or by average, and in almost every case, whether it be a felt washer or a front axle, a sample is sent into the laboratory for a mechanical and chemical diagnosis.

I believe we destroy more parts in testing than any other car factory. Of course, wherever possible parts are analysed without spoiling them, in which case they are returned to stock.

The chemical and metallurgical control even goes so far as the supply of lubricating oil to Ford dealers, which has been analysed and found up to specification. Again the metallurgical department are always in close touch with the service department for advising dealers on spurious parts, for where a dealer can say that a part is true to size, none of the senses usually attributed to the human race is capable of giving a verdict on its chemical composition. This is a necessary part of our work, for all Ford parts are easily identified, and in isolated cases of such parts being defective, we identify the part and immediately take the matter up with the particular manufacturer, whether it be ourselves or an outside supplier, with a view to eliminating a recurrence. With this end in view all dealers are encouraged to submit the fullest information on such cases so that preventive measures can be applied.

LAUNCH VELOCITIES AND DRAGS.*

By Professor PERCY A. HILLHOUSE, D.Sc.

THE problem of the launching of a ship into restricted water is one which is of peculiar interest to shipbuilders on the upper reaches of the Clyde. At Govan the river has a breadth of about 450 ft., and in order to obtain launching room the centre lines of the building berths have to be laid down at an angle to the line of the waterway, either up-river or down-river. The longest vessel which has been floated into the upper reaches is H.M. battle-cruiser Renown, nearly 800 ft. in length, and when this vessel came to rest after her launch her bow was 60 ft. clear of the way ends, while her stern was some 120 ft. from the stone wall of Merkland's Wharf, measured along the centre line of the launch. Owing, however, to the angle between the ship and the wharf the nearest portion of the quay wall was 60 ft. from the deck line of the cruiser, so that the net clearance was the same at either end. The centre line of the berth has since been still further inclined to the channel of the river, so as to permit of the safe launching of still larger vessels.

Such a fate is, of course, only made possible by the use of drags, piles of chain, or steel plates attached to the ship by cables or steel wire ropes which are of such lengths that they become taut when the vessel nears the way ends, and thereafter tow the drags over the surface of the yard and so create a resistance which slows and ultimately stops the vessel. The problem which faces the builder is to proportion the weight of the drags to the weight of the vessel and declivity of launch, and to determining the positions at which they will come into action, so that the resistance of the drags is withheld until the vessel is safely clear of the ways and is then called into play in sufficient amount to stop the vessel neither too soon nor too late. If too soon, the tension of the drag wires may pull the bow of the ship into contact with the shore and the way ground; if too late, the credit of stopping the vessel may be claimed by the opposing quay wall.

Both of these extremes have been experienced. In one case, that of a comparatively light vessel, a wire was led from a drag through one hawse pipe, round a

* Paper read before the Institution of Engineers and Shipbuilders in Scotland, November 21, 1922.

deck house, and out through the other hawse pipe to a second drag. The wire snapped, slipped out of both pipes, and left the ship free. She was brought to rest by a wooden wharf and sustained some damage to her rudder, stern post and propeller.

The determination of the weights of drags to be used in any particular case, and the fixing of their positions, is naturally not an exact science. It must be based largely on experience and the careful study of the recorded data of previous launches. The force causing the ship to move is her own weight; her motion is restricted by the friction of the ways, the resistance of the water, and by the inertia of the drags and their friction on the ground. The moving force is readily calculable; the resistances are more or less uncertain. Water resistance is an important factor, and the distance through which the vessel moves before water resistance comes into play upon her hull, and on the sliding ways and after poppets, has no doubt a considerable effect upon her velocity and the distance through which the drags will be moved. The work done by the vessel from start to finish of her motion will be proportional to her weight Δ and to the total fall h of her centre of gravity, while the work expended in moving the drags will vary more or less as the product of their weight D by the distance m over which they are moved. *Ceteris paribus*, the ratio of Dm to Δh, might reasonably be expected to be fairly constant. In practice I have found values ranging from 0·02 to 0·35, an average value for merchant vessels being 0·25. It is difficult to account for the variations, and even for sister ships, launched under nearly identical conditions, large differences manifest themselves in the value of the coefficient

$$C = \frac{Dm}{\Delta h}.$$

The Assiniboia, a vessel 336 ft. in length by 43 ft. 6 in. in breadth, had a launching weight of 1,650 tons, was 18·6 ft. lower when afloat than when on her berth, and pulled 60 tons of drags a distance of 62 ft. The Keewatin, a sister ship, was 100 tons lighter, fell 19·3 ft., and yet carried the same weight of drags more than twice as far. One vessel was launched in June, the other in July, and the only important difference in the circumstances of the launches were that the second vessel had 17 in. less water over the way ends. It is, therefore, possible that the second vessel was moving more rapidly than the first at the moment when their sterns entered the river and water resistance commenced to have effect.

The Empress of Asia was 1·3 per cent. lighter at launch than her sister the Empress of Russia, and both dropped through the same vertical distance; the water level over the way ends differed by 1 in. only. The former moved 460 tons of drags through 102 ft., while the latter shifted the same weight over 79 ft. only, the values of C being 0·252 and 0·198 respectively, the months of their respective launches being August and November. The pressure on the launching triggers was measured by means of the compression of small calibrated discs of copper inserted between the triggers and the snugs on the sliding ways, and was found to have been 103 tons or 0·304 of the component of the ship's weight in the direction of movement for the Empress of Asia, and 90 tons or 0·254 of the component for the Empress of Russia. It is possible, therefore, that the faster launch of the Empress of Asia was due to the launching lubricants being less viscous, due to the higher air temperature of August as compared with that of November. The copper discs show that the fraction of the component of the ship's weight taken by the triggers is seldom more than one-half, the largest value recorded at Fairfield being 0·56.

If the values of the product Dm, weight of drags by distance moved, be plotted on a base of Δh, weight of ship by vertical fall, some idea of the run of the coefficient C may be attained, and if logarithmic squared paper be used, it is found that the spots lie approximately in straight lines. By drawing straight lines through the thick of the spots I have obtained the following equations:

For destroyers, submarines, and small craft:

$$Dm = 0{\cdot}56\left(\frac{\Delta h}{40}\right)^{1\cdot3} \pm 18 \text{ per cent.}$$

For cruisers:

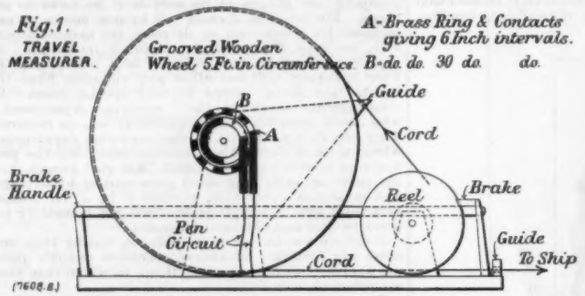
$$Dm = 0{\cdot}20\left(\frac{\Delta h}{40}\right)^{1\cdot4} \pm 15 \text{ per cent.}$$

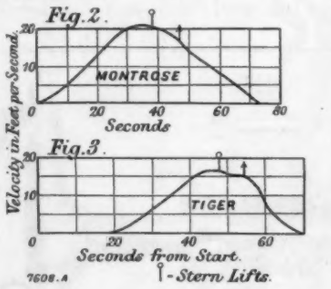
For merchant vessels:

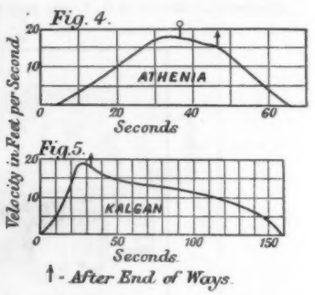
$$Dm = 1{\cdot}5\left(\frac{\Delta h}{40}\right)^{1\cdot2} \pm 25 \text{ per cent.}$$

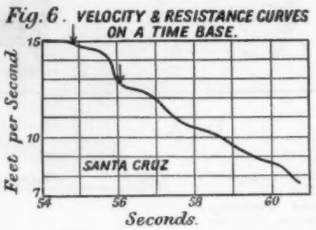
with occasional higher values, so that, owing to uncertainties, as to the height of tide, temperature of air, condition of ground, &c., it does not appear safe to predict the drag moment unless a possible variation of about 33 per cent. up or down is allowed for.

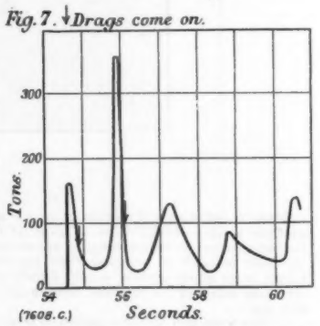
If there appears to be any danger of making the acquaintance of the opposite bank, it may be advisable to cause the vessel to swing round into line with the channel by attaching some, or all, of the drag wires to that side of the ship which is nearest to the building yard. At Savannah, Georgia, U.S.A., the 7,500-ton tanker Darden was swung through an angle of 60 deg. by means of one-side drags, and came to rest with her stern 1¼ of the ship's length away from a line perpendicular to the way ends. At the launch of the Mauretania, a wire from her after end was attached to an anchor buried in the mud of the river bed. The anchor was dragged a distance of 120 ft., but produced no appreciable effect in turning the vessel until she was nearly stopped. A similar drag was attached to H.M.S. Renown without noticeable result. At the launch of the Anchor liner Tuscania all the drags were attached to the starboard side of the ship, and when she came to rest after launch she was lying nicely parallel to the centre line of the waterway. The probable effect had been previously studied by means of model experiments, and although no measurements were made of the angle turned through, the actual launch appeared to confirm the model launch remarkably well. The weight of the model drags was in correct proportion to the weight of the model, and the roughness of the surface over which they moved was adjusted so that when the drags were placed equally on either side of the ship, they brought her to rest in the position expected. The model was given a way-end velocity corresponding to a speed of 18 ft. per second for the ship.











It has been the custom in many shipyards to record launching velocities in more or less detail. Sometimes only the time occupied by the vessel in travelling her own length is the only measurement made, and from this only the mean velocity on the ways can be obtained. This gives an idea as to whether the launch is "fast" or "slow." In a paper on "Launching Velocities," read before the Institution of Naval Architects forty years ago, Mr. William Denny gave curves of velocity plotted on distance and on time for eight vessels. Some of these were obtained by attaching a cord to the ship and guiding the cord, as it was set in motion by the ship, under a swinging pendulum with a heavy lead bob carrying a brush full of paint. The paint made marks on the cord at equal time intervals, and from the spacing of these marks the curves of velocity could be plotted. The method was not very satisfactory, as the marks—especially those which had followed the ship into the water—were not very clearly defined, and the contact of the brush with the cord tended to interfere with the proper timing of the pendulum.

In a better method the cord was passed around a wheel of known circumference, and this wheel geared to a drum carrying a sheet of paper upon which an electrically controlled pen made a mark every second. By screwing the axle of the drum and mounting it in stationary nuts a sideway motion can be given to the paper, so that the pen marks made during one revolution will be clear of those made during the previous round. In the course of the discussion on Mr. Denny's paper Sir Philip Watts described a method in which a cord attached to the ship was knotted at intervals and drawn under a wooden block, pivoted at one end, and held against the cord by a spring. To the block was fastened a light hammer which struck a bell every time one of the knots lifted the block. The times of the bells were called out by one observer with a watch and recorded by another.

At Fairfield a knotted cord was tried, and the passage of the knots electrically recorded, but the results were unsatisfactory, and a wooden wheel, Fig. 1, exactly 5 ft. in circumference, is now used. The cord is stowed upon a small reel, and is led around about three-quarters of the circumference of the wheel, and then to the ship. It is usually attached at about the deck level, a little forward of amidships, and the recording gear is placed on top of the workmen's gangway, or the string is taken over a guide block on the gangway and led down to the instrument at the ground level. This keeps the string clear of the water, and a brake acting on the reel keeps the cord as taut as possible. On each side of the wheel are two series of brass plates arranged in two circles. Each small circle consists of two plates, while each large circle has 20 plates, and in each case alternate pairs of plates are cross-connected through the wheel. Fixed spring contact pieces press against the circles on each side of the wheel, and carry electric current operating two pens marking a strip of paper moved by clockwork. The current pulls the pen to one side, so that one line drawn shows two steps, and the other ten steps per revolution of the wheel. These steps, therefore, correspond to ship movements of 2 ft. 6 in. and of 6 in., respectively. At the beginning and end of the launch, when the speed is comparatively low, the 6-in. pen is used, but during the faster middle portion it is switched out of gear, and only the 30-in. intervals are recorded. The clock works a third pen, marking quarter-second intervals. In order to have as accurate a record as possible of the initial movement, which is usually very slow, a wooden batten about 1½ in. square in section and 6 ft. in length was attached to the ship. One wire of a pen-working circuit was attached to the batten by a flexible lead, and then led zig-zag along the batten crossing one face at intervals of 1 in. The other wire was attached to a fixed spring-contact piece pressing against the wired face of the batten. The pen thus received a side pull at every inch of motion of the ship. The batten was connected to the fore end of the sliding ways by a single nail, and when the ship had moved 6 ft. the batten was held by a stop and the nail pulled out.

The launch velocity curves given by Mr. Denny, and already referred to, were not continued throughout the whole motion of the ship, so that only the speeds on the ways and for about 20 seconds afterwards appear on the curves. The vessels were launched without drags, except in one instance. Sir Philip Watts contributed to the discussion some curves showing the velocities throughout the whole motion. The time-distance curve was differentiated to obtain the velocities, and the time-velocity curve differentiated to give accelerations. Knowing the acceleration at the beginning, and the component of the ship's weight tending to set her in motion, the coefficient of friction of the ways can readily be deduced. A very complete set of such curves was published in *The Shipbuilder*, Vol. I, in connection with the launch of the Mauretania. The accompanying diagrams, Figs. 2 and 7, are reproductions of some of the Fairfield records. The curves were prepared with the object of studying the effect of the drags upon the motion of the vessel, but in some cases the velocity curve appears to be perfectly smooth, and the coming on of the drags does not produce the sudden change of direction which one would naturally expect.

It is not an easy matter to differentiate the curves of motion. The process is one of determining the slope of the curve, and unless the curve is very carefully drawn through closely-spaced observation points, the resulting curves of velocity and acceleration are somewhat uncertain. The reverse process of integration is much more definite, as it is a process of area measuring. As we had spots on the time-distance curve only 6 in. apart, and used paper squared in tenths of a centimetre, it was possible to make a very close analysis, and in some cases very rapid and large fluctuations were found to exist in the retardation curve. These are possibly due to pulsation and whipping of the drag wires. When the drag first comes on, its mass has to be accelerated, and the extra tension in the drag wire causes it to stretch. When the drag has been set in motion the excess of tension in the wire will cause it to move faster than the ship, and the wire will contract. The drag will then slow up, and the wire will again have to stretch to bring it along. The alternate stretching and contraction of the

wire will produce fluctuations in the curve of retardation. A close analysis was made of the final motion of the oil tanker Santa Cruz, and the rapid fluctuation of resistance is very noticeable, Figs. 6 and 7. The maximum velocity attained is generally about 18 ft. per second, as will be seen from records in the following vessels :—

Athenia	18·0
Tuscania	22·5
Tiger	17·0
Empress of Canada	17·8
Montrose	21·8
Santa Cruz	16·2
Kalgan	18·5

and occurs some distance before the fore poppet reaches the end of the ways. The velocity curve frequently exhibits a dip or flattening just beyond its maximum ordinate, due probably to the sudden loss of way friction when the stern rises, and then falls away rapidly owing to water and drag resistance.

In order to measure the maximum tension in the drag wires, we have made two special meters, consisting of strong wrought-iron links arranged so as to carry between their bearing surfaces a small copper disc, 1 in. in diameter and $\frac{1}{4}$ in. thick. By the amount of compression of this disc the maximum tension in the wire can be estimated, similar discs having been previously calibrated in a testing machine. Only one test has so far been made; the copper block was reduced to a thickness of about $\frac{1}{4}$ in., and the tension indicated was nearly equal to the nominal breaking strength of the wire. The result is probably not very reliable. The blocks were calibrated by successive increases of pressure applied slowly, while the tug of the drag wire would compress the block very quickly, and the influence of time on the flow of the copper in changing its shape introduces an unknown element. For this purpose it might be better to test the blocks by dropping weights upon them.

THE IMPROVEMENT OF POWER FACTOR.*

By the late Dr. GISBERT KAPP.†

(*Concluded from page* 694.)

Meters and Tariffs.—More than ten years ago Professor Arno, of Milan, invented a meter which takes account of power factor in the following way. The meter registers on the same dial two-thirds of the true energy plus one-third of the k.v.a.-hours. This is achieved in a simple and quite inexpensive way by adjusting the angular setting of the pressure coil.‡

The values two-thirds and one-third have been arrived at by investigation of the working conditions of a number of Italian supply companies and may, on the whole, have correctly represented the economic conditions of the Italian hydro-electric undertakings. It is, however, not *a priori* certain that it would also be correct for English electricity works. At any rate this system of metering has not found favour in this country. Possibly also, the fact that the consumer could not read off on this meter what was actually the energy for which he had to pay, was a drawback. Both these disadvantages have been overcome of late years by a further development of the Arno principle which will be described later.

In this country two methods of charging have been employed. The one is known under the name of "Midland tariff." Under this, the charge for energy consists of two parts, namely, a fixed amount per maximum demand for k.v.a. or current taken at any time during a month or a quarter, plus a flat rate per unit for the energy actually consumed. This requires the provision alongside of the ordinary cosine meter of a maximum-demand indicator which must be so constructed that only a demand sustained over a reasonable time can influence it, as it would clearly be unfair to penalise the consumer for an accidental short-circuit. The advantage of this system is that the consumer can read for himself on the energy meter what amount under the flat rate he will have to pay, and on the maximum demand indicator what the fixed charge per k.v.a. will total up to.

Under the other system, also, two meters are used. One reads true energy, namely

$$\int_0^t \text{k.v.a.} \cos\phi \, dt = \text{A}$$

and the other reads

$$\int_0^t \text{k.v.a.} \sin\phi \, dt = \text{B}.$$

From these two readings the average energy factor is found by the equation

$$\cos\phi = \frac{\text{A}}{\sqrt{(\text{A}^2 + \text{B}^2)}}$$

and the charge is made out for a flat rate and for the quantity

$$\text{Q} = \text{A}\frac{\cos\phi_0}{\cos\phi},$$

which is obviously nothing else than total k.v.a.-hours multiplied by $\cos\phi_0$. Since $\cos\phi_0$, the lowest permissible power factor prescribed by the company, is a constant the company simply charges at a flat rate for the number of k.v.a.-hours or, if the voltage may be considered constant, for coulombs. In both tariffs the usual coal clause and discount to large consumers can be embodied.

A method not quite as simple as Arno's, inasmuch as it requires two meters instead of one, is in use by some supply companies in France. Arno's meter integrates and shows on one dial two-thirds of the real power and one-third of the k.v.a.-hours. In the French method one meter shows the real energy and the other the reactive energy or $\int$k.v.a. $\sin\phi \, dt$. The account is made up on a flat rate on the sum of the units registered on the cosine meter plus a certain fraction of the units shown on the sine meter. Here also, as in the case of the Midland tariff, the customer can by inspecting his meters find out for himself not only what is the actual amount of energy he has used, but also what he has to pay for it. The meters are made by the Compagnie pour la Fabrication des Compteurs of Paris in a great variety of types and comprise also a special type, having three dials, for large consumers. On one dial is shown the actual energy, on the other the reactive energy, and on the third the sum of the real and a fraction of the reactive energy. The exact value of this fraction is agreed beforehand between the supply company and the consumer according to the character of his intallation, and is provided for by the selection of suitable gearing.

The firm of Messrs. Aron Electricity Meter, Limited, manufactures the Hill-Shotter maximum-demand k.v.a. indicator for use in conjunction with the ordinary cosine meter. Since the plant capacity from the generator to the consumer's terminals is dependent on the current irrespective of pressure and frequency, the instrument is made to register simply the maximum current sustained during a certain time interval, although the dial is marked in k.v.a. corresponding to the declared pressure. The demand indicator is arranged on the Merz principle, the releasing mechanism being tripped at regular time intervals by an automatic clock mechanism which is worked by a shunt circuit off the supply leads. The time element is housed in the same case as the meter proper; and since the working agent is merely current, the indication is correct for any frequency. For balanced loads the instrument may be used in one phase only, but in cases where the supply given to unbalanced loads has to be metered a special three-phase type is made.

In such cases the maximum demand does not occur in all phases at the same time, and the sum of these maxima must exceed the true simultaneous maximum. The supply company, however, has to provide plant capacity in each phase corresponding to its individual maximum and not for the simultaneous maximum loading in all the phases combined. If with a balanced load 300 amperes were the combined maximum demand, it would obviously be inadmissible to allow 150 amperes on each of two cables and zero on the third. In such a case of serious unbalancing the use of three maximum-demand indicators is justified. For only moderately unbalanced loads the makers recommend a combined polyphase indicator containing three separate current elements, and this indicator is accurate provided the unbalancing is not so great that at times of maximum load the current in any one phase does not differ from the mean value of the currents in the other two phases by more than 50 per cent. of that mean value.

The firm of Messrs. Chamberlain and Hookham, Limited, has recently developed minimum and maximum energy factor indicators which require no time mechanism. The minimum instrument consists of an ordinary cosine meter and a sine meter having, in addition to the usual pointer, an indicator. The cosine meter has a contact-making device which comes into action after a predetermined amount of energy has passed through the meter. In the sine meter is an electromagnet which, when energised, releases the gear and allows the pointer to return to zero under the action of a spring, the indicator remaining at its then position. Suppose the contact has been set for 10 units. Every time this amount of energy has passed the sine meter returns to zero and, since the lower the energy factor the further will the indicator be pushed, its extreme position corresponds to the minimum energy factor which has occurred during a given period. The dial of the sine meter may be marked either in k.v.a.-hours or directly in $\cos\phi$. To record the highest energy factor occurring in a given time the contact device is put into the sine meter and the $\cos\phi$ indicator into the cosine meter.

In order to ascertain the general trend in the supply industry as regards discriminative tariffs, the author has made inquiries of some of the larger power companies with the following results. On the whole the importance of framing the tariff so as to induce consumers to take their supply under a good power factor is recognised, but the question is (owing to the unsettled industrial condition) still in a state of flux. Thus one company writes that previous to the war they charged 1*l.* per quarter per k.v.a. of maximum demand plus a flat rate of 0·25*d.* per unit, but that owing to the increase in prices they had to advance their charges and, everything being so uncertain, they prefer not to state any definite figures.

Another company writes with respect to tariff adjustments according to power factor: "It will be inopportune for you to refer in your paper to the figures we gave you last year, having regard to the possibility of it now being found necessary to amend them."

The engineer of a third undertaking, who wishes to remain anonymous, though he permits me to mention his figures, explains that he uses two cosine meters, one with the pressure phase reversed, so as to get not the sum, but the difference in the two-wattmeter system. From the two readings he finds tan ϕ and from this $\cos\phi$. The units shown on the true energy meter are increased in the ratio $0{\cdot}8/\cos\phi$ and half this increase is charged in addition to the true units.

The South Wales Electrical Power Distribution Company charges on the basis of the following figures per maximum k.v.a. demand (reduced from true energy by dividing by the energy factor) plus a flat rate of 0·25*d.* per unit:

For the first 500 maximum hourly units per month 7*s.* 6*d.* each.

For the next 1,500 maximum hourly units per month 6*s.* each. For all further hourly units per month 5*s.* each.

It is convenient to put this tariff into mathematical form. Let D be the maximum demand in units, *d* the flat rate per unit, U the units of true energy consumed in one month, and $\cos\phi$ the energy factor. Then the monthly charge in pence is:

For D up to 500,

$$\text{Pence} = \frac{1}{\cos\phi}\left\{a\,\text{D}\right\} + d\,\text{U}.$$

For D between 500 and 2,000,

$$\text{Pence} = \frac{1}{\cos\phi}\left\{a\,500 + a_1(\text{D} - 500)\right\} + d\,\text{U}.$$

For D over 2,000,

$$\text{Pence} = \frac{1}{\cos\phi}\left\{a\,500 + a_1\,1{,}500 + a_2(\text{D} - 2{,}000)\right\} + d\,\text{U}$$

$$a = 90,\ a_1 = 72,\ a_2 = 60.$$

The North Wales Power and Traction Company write: —"Our standard price at present (March, 1922) is 6*l.* per kilowatt of maximum demand plus $\frac{1}{4}$*d.* per unit; and in the case of bulk supply we specify in the power agreements that the power factor shall be kept as near unity as possible. With industrial works supply we specify that the power factor shall not be less than 0·85, and secondary equipment is installed to our reasonable satisfaction, so that we can take exception to any plant which gives poor power factor."

The Yorkshire Electric Power Company write:—"Our tariff for power supply is made up of two parts: (1) A charge per k.v.a. of maximum demand. (2) A charge per unit. This tariff definitely encourages the consumer to have regard to the power factor of his installation, and in a number of cases consumers find it economical to introduce special means for improving the power factor of their installations."

The Scottish Central Electric Power Company write:—"This company has not so far introduced a tariff to induce consumers so to arrange their plant as to provide a good power factor. We have the usual 'Penalty Clause' in respect of low power factor in our agreements for supply, but, owing to the difficulty of enforcing this, it is rarely brought into operation."

The City of Sheffield has a tariff for power based on a fixed charge per maximum demand in k.v.a. and, in addition, a flat rate per unit, with discounts varying according to quantity. The rates originally published in 1913 have now been doubled, and the charges made to large consumers taking a high-tension supply in bulk for any purpose required amount at present (March, 1922) to a fixed charge of 8*l.* per annum of maximum demand in k.v.a. and a flat rate of 2*d.* per unit, less a discount of 75 per cent. The rate is subject to the signing of an agreement embodying a clause adjusting the discount according to the price of coal, also a minimum payment per annum and a term of years.

The Calcutta Electric Supply Corporation limits consumers to a power factor of 0·8, and the consumer obtains a bonus if his power factor is better than 0·85. The bonus is in the form of a rebate for each 1 per cent. by which the power factor exceeds 85 per cent.

The Clyde Valley Electric Power Company have given me the following particulars about power factor and tariff, with permission to embody them in this paper: "The mean power factor of our system averages about 0·72 over a week, ranging from about 0·55 to 0·82 daily. We estimate that the increased loss in our 11,000-volt distribution system due to the difference between unity power factor and the power factor obtained is 3$\frac{1}{2}$ per cent. The increased loss in transformers and generating plant we put at 0·6 per cent. and 0·75 per cent. respectively, or a total increased loss of 4·85 per cent. To this must be added the increased steam losses consequent on running additional turbo plant to deal purely with the k.v.a. demand. A further direction in which we estimate that we suffer considerable loss in revenue is the impaired voltage regulation at the customer's terminals due to the lower power factor. The company, therefore, some time ago decided to insert a Power Factor Clause in the standard rates. After careful consideration a 'standard power factor' of 0·8 lag was adopted. The present standard rates are:—

"0–250 kw. of maximum demand: 10*l.* per annum, plus a running charge of 0·4*d.* per kilowatt-hour consumed with coal at 20*s.* per ton.

"1,000 kw. of maximum demand: 8*l.* per annum, plus a running charge of 0·4*d.* per kilowatt-hour consumed with coal at 20*s.* per ton.

"10,000 kw. of maximum demand: 6*l.* per annum, plus a running charge of 0·4*d.* per kilowatt-hour consumed with coal at 20*s.* per ton.

"And *pro rata* for intermediate quantities.

"The power-factor rebate is given on the maximum-demand charge, the running charge of 0·4*d.* being unaffected. With a standard power factor of 0·8 the rebate obtainable with unity power factor is 20 per cent. With a power factor of 0·6 lagging, the penalty becomes 33$\frac{1}{3}$ per cent., in addition to the maximum-demand charge. In the case of a customer with a maximum demand of 1,000 kw., the rate per kilowatt at unity power factor would be 6*l.* 8*s.*; and with 0·6 lagging power factor it would be 10*l.* 13*s.* 4*d.*; the running charge of 0·4*d.* per unit being additional in both cases. The rebate is given up to unity power factor, and no allowance is made for power factors on the leading side, these being treated on the same basis as unity power factor. We have given careful consideration to the question of metering the power factor, and the system which we consider introduces fewest difficulties

* Paper read before the Institution of Electrical Engineers, on November 16, 1922.

† Dr. Kapp died on August 10, 1922.

‡ *Journal I.E.E.*, 1913, vol. li, page 270.

in our accounts department is the method of registering the wattless component. The metering of power is accomplished by the three-wattmeter method, and to measure the wattless component only requires the addition of one further wattmeter, which does not in any way interfere with the ordinary metering. We arrange the connections of this wattmeter so that the reading is forward for lagging and the reverse for leading power factor. The wattless component and the kilowatt meters are read at the end of each quarter, and the power factor is determined from the relation of the respective readings. Our Mr. McColl has designed a slide rule with which the power factor can be readily determined by any non-technical person. The method of power-factor metering which we have adopted gives the consumer the advantage of off-time phase-advancing; that is to say, where static condensers are employed these may be left in circuit continuously, and the wattless component which has been registered on the lag side may be cancelled during off hours by the leading current of the condensers."

The examples of tariffs cited show that the tendency in the supply industry is rather in the direction of a fixed charge for the maximum demand, augmented by a flat rate per unit, than only a flat rate adjusted according to power factor. The latter is unscientific and can, under circumstances, be unfair to either the consumer or the company, as can easily be seen if we consider two cases which may well arise in practice.

Assume that a consumer installs only synchronous induction motors. His power factor will always be leading, and on a flat rate based on and proportional to $\cos \phi_0/\cos \phi$ he will always pay too much. Yet as long as his neighbours have a lagging power factor he is benefiting the supply company. Only in the unlikely case that all consumers were to use the whole supply to work phase-advancing motors would the company also be injuriously affected.

On the other hand, a consumer may use ordinary motors and correct the general power factor of his whole installation by static condensers. With a load factor of 0·23 he will consume, every working day of 8 hours, 660 units for every 100 kw. of his peak load. Under a tariff which allows him an energy factor of 0·85 without penalty he will be able to make the necessary correction by installing condensers, but he will not install more than are absolutely necessary. His mean load is 0·83 of the peak load, and his power factor at peak load may be as low as 0·7. Taking this as a reasonable figure, we find that at peak time his condensers will have to inject 39 k.v.a. for every 100 kw. of peak load. If he leaves the condensers in circuit for 24 hours a day he can reduce their capacity to one-third and yet keep within the permissible power factor of 0·85. But at peak time his power factor will be only 0·78, and as the intention of the tariff is to make the consumer pay his fair share of the additional current load on the plant at peak time, he ought to pay $0{\cdot}85/0{\cdot}78 = 1{\cdot}11$ times the minimum rate. Actually he only pays the minimum rate. The company receives 11 per cent. less than corresponds to the intention of the tariff.

Such anomalies cannot occur under a maximum-demand tariff. The consumer may leave his condensers in circuit permanently without depriving the company of a certain precentage of the revenue to which they are entitled, because the fixed charge is not influenced, or is only slightly influenced, by energy factor. For the same reason the consumer cannot be penalised for doing a little more phase advancing than is necessary. The basic idea of the two-part tariff is that the fixed charge for maximum demand should recompense the company for capital outlay incurred on account of each consumer, whilst the flat rate per unit should recompense them for running costs. If the voltage at consumers' terminals is kept constant, the maximum k.v.a. demand can be found from a maximum-current indicator scaled in k.v.a. Under these conditions the metering becomes a very simple matter. All that is wanted is a coulomb meter combined with a time element which brings the pointer back at regular intervals of 10 minutes or 20 minutes, leaving the indicator in its farthest position, and an ordinary cosine energy meter. Neither energy factor nor power factor enter in the making up of the total charge, and the customer can by inspection of the two meters find out for himself what energy he has used during a month or a quarter and how much he has to pay for it. This is an advantage, especially with small consumers, who cannot be expected to understand the mathematics of power and energy factor.

The condition of constant terminal voltage may not, however, be strictly maintained. If the voltage is higher than the declared voltage on which the maximum demand indicator is scaled, the number of k.v.a. read off the indicator and also the fixed charge, will be too low, to the detriment of the supply company. If the terminal voltage decreases, the indicator will show too large a value for the maximum k.v.a., to the detriment of the consumer. The greatest voltage-drop occurs at peak time and, generally speaking, this is the time when consumers individually have their own peak demand. The result is that the fixed charge will be in excess of that for the true maximum k.v.a. demand in the same percentage as the actual voltage falls short of the declared voltage.

The error thus introduced by excessive voltage-drop may be appreciable and, as it is always against the consumer, we find that most supply companies do not use the simple (coulombs)/(time) indicator, but replace it by a (units)/(time) indicator, and translate the reading into maximum k.v.a. demand with reference to the energy factor by dividing the number of units by $\cos \phi$. Under this more accurate system of metering three instruments are required: (1) A maximum demand kilowatt indicator which is a cosine meter with a time element; (2) an ordinary cosine energy meter; and (3) a sine meter to record $\int E I \sin \phi \, dt$. From the two last-named instruments is found $\tan \phi$, and from this $\cos \phi$.

If P_0 = maximum kilowatt demand,
P = maximum k.v.a. demand,
m = charge per maximum k.v.a. demand,
U = number of units consumed,
d = flat rate, then

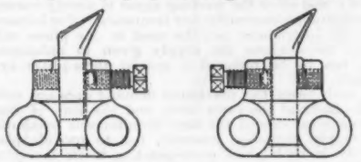
$$P = \frac{P_0}{\cos \phi}; \text{ and the total charge} = m P + d U.$$

Under this tariff there is no necessity to place the consumer under any restriction as to a minimum power factor. The latter may be as bad as suits the consumer's method of working his machinery, because its effect will make itself felt in the energy factor and thus appropriately increase the fixed charge, thereby recompensing the supply company for their greater expenditure on electrical plant.

In conclusion the author thanks the various firms and engineers of power supply undertakings for the information which they have kindly supplied to enable him to present his paper.

FIXING THE CUTTER PICKS OF CHAIN COAL-CUTTERS.

The set-pins that fasten the picks in their sockets in chain coal-cutters should be so inserted that the point of the set-pin tightens on the front of the shank of the pick, thus pressing the back of the shank against the wall of the socket. In Fig. 1 (A) and (B) show the right and the wrong place to insert the screws, and also show why the right way is right and the wrong way is wrong. When the pin is properly inserted the force that keeps



(A) Fig. 1. (B)

the cutter, when in operation, up to the work is applied from the wall of the pick socket directly to the shank of the cutter. When the pin is inserted on the wrong side of the pick the force that drives the pick is applied through the point of the pin, and the vibration and shocks to which the pin is subjected tend to loosen the pin and so allow the pick to come out of its socket.

It is usual to make the pins of tool steel and to "cup" and harden their points so that, when screwed firmly against the shank of the pick, the edge of the cup bites into the metal and tends to bind the pin to the pick; but in hard holings, especially where pyrites or ironstone nodules occur, the pins even when properly placed may be loosened.

The severe shocks and jarring of the picks when cutting very hard materials cause minute movements of the pick; these small but rapidly repeated movements tend to slacken the screw so that the point of the pin loses its grip of the pick. To prevent this slackening of the screws and the consequent loss of picks, a number of devices have been tried. An effective method suggested by one of the operators of Messrs. Mavor and Coulson, Limited, Mr. Rankin, is illustrated by Fig. 2. In this

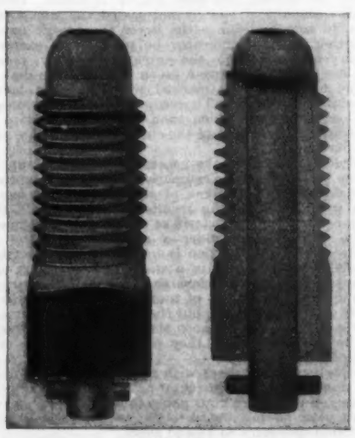


Fig. 2.

arrangement the cupped and hardened point is formed on a separate piece, with a stem which passes freely through a hole drilled in the set-pin and is kept in place by a small split pin, as shown by the sectional view.

In operation the hardened head of this separate piece with its cupped point, not being rigidly attached to the set-pin, is free to make minute movements relatively to it. The friction at the contact of the cupped point with the cutter pick is much greater than that between the machined faces of the end of the screwed pin and the hardened head; therefore when the pick is subjected to shocks which cause it to shake in its socket, the hardened head whose cup edge has bitten into the pick, follows the pick in its slight movements without communicating the twisting action to the screwed pin, the slackening of which is thus prevented. After this device had been adopted and put in practice it was learnt that the same principle, by another method, had been quite independently applied in the North of England.

Although perfectly effective in its purpose the form illustrated by Fig. 2, and also the other form to which we have referred were open to the objections that they involved drilling a small hole through the screwed pin, either axially or at right angles to the axis, and that the small detachable parts were liable to be lost.

To overcome this Messrs. Mavor and Coulson devised, and protected by patent application, the extremely simple and effective embodiment of the principle illustrated by Fig. 3. The point of the screwed pin is recessed to admit a hardened steel ball, with a flat formed on it to bear on

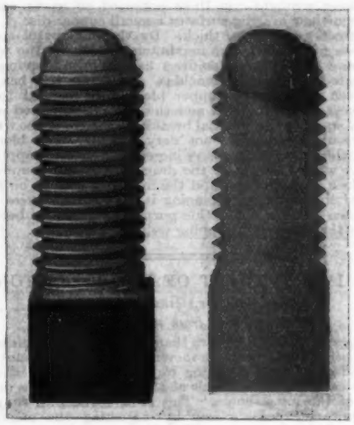


Fig. 3.

the bottom of the recess; the opposite side of the ball is cupped to present a biting edge to the pick, and the outer end of the wall of the recess is pressed inwards to keep the ball in position, as shown by the sectional view.

The free points of these pins are formed from standard balls as manufactured for ball bearings. On one side of the ball the flat is ground and on the other side the cup. This method adapts a standard product to a new purpose for which it is singularly well suited. The advantages are appropriated of the excellence developed in manufacture of the balls, which are uniformly high in quality of material, of degree of hardness, of form, and of finish. These qualities endow the balls with shock and pressure resisting properties greatly superior to those of the tempered points of tool-steel pins.

Moreover, the convex curve of the ball gives ideal support for the biting edge, and the highly polished surface adds materially to the ability to support pressure.

Fig. 4 illustrates in full size the impressions made by the cupped edge of a ¾-in. pin.

(A) shows a bar of mild steel into which the point of the pin (D) was forced until the whole exposed surface of the ball was embedded, the side of the steel bar being bulged by the pressure. The piece at *a* shows the impression produced in a Brinell hardness testing machine by a pressure of 3,000 kg. in a 10 mm. ball; the Brinell hardness number corresponding to the impression being 241. B shows the penetration of the high carbon steel cutter pick of a chain coal-cutter by the same point D, effected by hammering on a spanner engaged with the square head of the pin, to destruction of the screwed pin, but without the slightest trace of damage to the cupped edge of the ball. The impression made at *b* by the Brinell machine with a load of 3,000 kg. on a 10 mm. ball corresponds to the hardness number of 269.

One cause of damage to the cupped point of the ordinary pinching pin is that the cup is seldom precisely concentric with the axis of the pin. When the screwed pin is turned and the cup is forced against the object to be secured, the effect of even a small degree of eccentricity is to put upon the edge of the cupped point such side stress as is liable to damage or break it. In the case of the free-point pin, the permissible movement between the flat base of the ball and the screwed pin accommodates such irregularities, and saves the cupped ball from all stress except compression—this is one of the reasons for the remarkable immunity from damage, and the durability of the biting edge of the free-point pin.

To demonstrate that the ball does not turn with the pin but penetrates without any angular movement, a cross was ground in the hollow of the cupped point of a pin E, Fig. 4, and by turning the pin as described above, the point was forced into the mild steel bar C. The sharply moulded X in the impression on the bar, shows clearly that under the greatest possible pressure the screwed pin turns upon the flattened base of the ball, and that conversely the ball-point is free to make the small angular movements independently of the pin, which prevent the slackening of the latter.

This simple contrivance provides a screwed pin with

the desired hardened point, free to make angular movement independently of the pin, and it has proved to be a wholly satisfactory solution of the problem.

Anyone who has trouble from the loss of chain coal-cutter picks can definitely stop it by the use of these free-point pinching-pins. The loss of the value of cutter picks is not the whole consequence of picks coming out of a chain. The absence of the picks results in excessive strains on the machine due to the lack of necessary cutting points, and that usually in the hardest materials, for which all the cutting points are most needed.

These freepoint pinching-pins, in addition to their secure grip of the cutter pick, have the advantage that

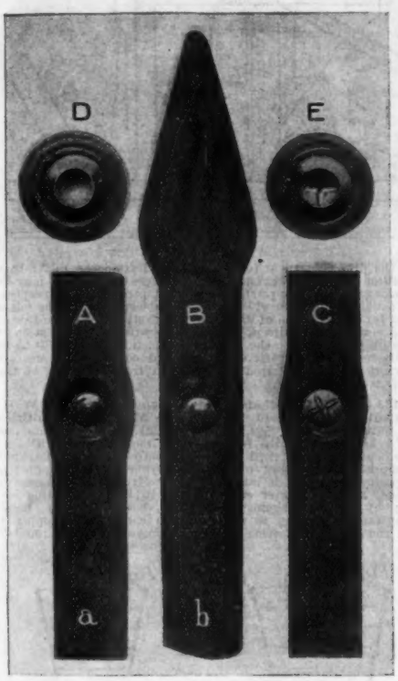


FIG. 4.

they do not require to be tightened on the pick to anything like the degree necessary with the ordinary set-pins; the time and effort expended in changing cutters are thus materially reduced, and the life of the set-pin is prolonged.

By applying the freepoint pins anyone who, with any make of chain machine, is losing picks because the ordinary screwed set-pins will not hold them, can find complete relief from the trouble.

A LARGE OIL-ENGINE CONTRACT FOR LINCOLN.—The difficulties which exist with regard to foreign trade at the present time make it pleasant to record the success of Messrs. Ruston and Hornsby, Limited, of Lincoln, in obtaining a contract for the supply of 32 oil engines to the order of a foreign Government for use in the oilfields. These engines are of the horizontal single-cylinder cold-starting "Ruston" type, each rated at 130 b.h.p. at 175 r.p.m. The engines, the first of which has passed its official tests, are designed to run alternatively on fuel oil or on natural gas. To provide for the lower compression required when natural gas is used as fuel, the connecting rod is shortened by the removal of a distance-piece at the big end of the connecting rod. The complete change from one fuel to the other can be effected in 12 minutes. The engines will start on fuel oil instantly from cold, no starting lamp being required, and the consumption of oil at normal load does not exceed 0·42 lb. per brake horse-power hour.

MOLYBDENUM VACUUM FURNACE.—The molybdenum resistance furnace for high temperatures, which P. Fleury describes in the *Comptes Rendus* of November 13, consists of an alundum tube, wound outside with molybdenum wire, 1·2 mm. in diameter. Though molybdenum is more volatile and more fusible than tungsten, it is less brittle and hence easier to wind. The tube is spirally grooved, the grooves being 2·5 mm. wide, and the wire is embedded in an alundum cement. An outer tube, also of alundum, is slipped over the inner cylinder, and the whole is placed under a bell of an air pump; a high vacuum is maintained by the aid of rubber packing. The inner cylindrical space is the furnace. The first heating of the furnace should be very gradual, because the gases evolved might injure the wire; it is best to heat for a few days slowly up to 1,500 deg. C., while keeping the gas pressure under the bell at 50 μ or less. A furnace, 4 cm. in diameter, 14 cm. high, can afterwards bear 1,600 deg. C. for several hours, and 1,700 deg. for half an hour. At temperatures above 1,750 deg. the alundum begins to fuse.

CATALOGUES.

Clutch.—A new design of rim clutch is described in a catalogue issued by Messrs. Casey, Bean and Cassells, Bradford, and 63, Queen Victoria-street, London, E.C. 4.

Electric Switch Gear.—A revised price list of low and medium-tension switch gear has been issued by the General Electric Company, Limited, Kingsway, London, W.C. 2.

Ironing Machine.—A wall card illustrating their steam-heated Decoudun ironing machine for laundry work is to hand from Messrs. Manlove, Alliott and Co., Limited, Nottingham.

Air Compressors.—A coloured diagram illustrating the construction of the main working parts of their piston-type air compressor is to hand from Messrs. Broom and Wade, Limited, High Wycombe.

Electric Fans, &c.—Circulars with details and prices of several types of ventilating fans and an alternating-current rectifier for battery charging are to hand from Mr. M. W. Woods, 146, Bishopsgate, London, E.C. 2.

Boiler Testing Outfit.—Particulars of a full set of instruments and tools used in boiler testing have been issued by the sales department of the National Boiler and General Insurance Company, Limited, Manchester.

Locomotives.—Several types of locomotive, especially suitable for service in gas works, are illustrated and described in a special catalogue issued by the makers, Messrs. Andrew Barclay, Sons and Co., Limited, Kilmarnock.

Fire Cement.—Fire-resisting cement for setting or repairing the firebrick work of all kinds of furnaces and fireplaces is dealt with in a catalogue received from Messrs. J. H. Sankey and Son, Limited, Canning Town, London, E. 16.

Radial Drilling Machines.—A description of their high-speed radial drilling machine, with particulars of attachments for special work and tables of capacity, has been issued by Messrs. Kitchen and Wade, Giblet-street, Halifax.

Steel Furniture.—A catalogue of neat and strongly made tables, shelves, bins, racks, cupboards and similar articles of sheet steel construction is to hand from Messrs. G. A. Harvey and Co. (London), Limited, Woolwich-road, London, S.E. 7.

Circuit Breakers.—A catalogue of ironclad oil-immersed circuit breakers, of the flame-proof type and suitable for mining and general industrial use, has been received from Messrs. Ferguson, Pailin, Limited, Edward-street, Higher Openshaw, Manchester.

Tea Machinery.—Machines for cleaning and grading tea, with appliances for removing foreign material, and also tea-mixing machines, are represented in a catalogue received from Messrs. Henry Pooley and Son, Limited, John Bright-street, Birmingham.

Viscometer.—A new edition of their catalogue describing the construction and use of the appliance made by them for testing the viscosity of lubricants, varnishes, &c., comes from Michell Bearings, Limited, 3, Central Buildings, Westminster, London, S.W.

Steel.—The United Steel Companies, Limited, Sheffield, have sent us a copy of a booklet containing a list of their fifteen associated companies and giving notes of the principal products of each, with the addresses of their home district offices and foreign sales agencies.

Densimeter.—A further catalogue of their instrument of the water-gauge type for indicating in parallel glass tubes the level and density of the water in a steam boiler has reached us from the Chemical Engineering Company, Limited, 49, Deansgate, Manchester.

Protection Paint.—The advantages in cost and efficiency of a protective and anti-corrosive paint made principally of oxide of aluminium, are explained by the makers, The Redaluma Paint Company, Limited, 1, Lloyd's-avenue, London, E.C. 3, in two circulars.

Ball Bearings.—Journal and thrust ball bearings and balls are listed and priced in a series of clearly arranged tables, contained in a compact catalogue issued by Messrs. Rudge-Whitworth, Limited, Sparkhill, Birmingham. Some useful technical information is also given.

Electric Starting Panels.—Ironclad motor starting panels for all voltages up to 550, with several automatic safeguards against improper starting, are described in a new catalogue received from the Igranic Electric Company, Limited, Bedford, and 147, Queen Victoria-street, London, E.C. 4.

Switch Gear.—A new and handsomely illustrated catalogue of power-house and substation switch gear, including illustrations of numerous colliery and municipal station switchboards, has been received from the English Electric Company, Limited, Queen's House, Kingsway, London, W.C. 2.

Wire Wheels for Motor Cars.—The construction of the wire wheel is very clearly explained and illustrated with dimension tables in a catalogue issued by Messrs. Rudge, Whitworth, Limited, Coventry, who also send a price-list of a very large range of standard wheels for light, medium and heavy types of motor cars.

Rock Drills, &c.—Three sectional catalogues dealing with hollow and solid bits for rock drills, coal-cutter picks, snaps and chisels for pneumatic tools, hand hammer heads and other similar steel products, have come to hand from Messrs. Padley and Venables, Limited, Dominion Steel and Tool Works, Sheffield.

Air Heater.—The advantages of using waste gases from the chimney to heat the air supply for boiler furnaces and other applications of the same principle, are set forth in a catalogue received from the Emile Prat-Daniel Company, Paris, represented by Mr. S. Utting, 82, Victoria-street, London, S.W. 1.

Wind-Driven Electric Lighting Plant.—A complete plant for generating current for electric lighting by means of a windmill and including a storage battery for several days' supply in case of wind failure, is described in a priced catalogue received from the Glasgow Engineering Company, Limited, 45, Pitt-street, Glasgow.

Telephones.—An extremely comprehensive catalogue of telephones, telephone parts and accessories, is to hand from Messrs. Siemens Brothers and Co., Limited, Woolwich, London, S.E. 18. The catalogue seems to include every possible requirement in connection with telephone installations, and is provided with a good index.

Auxiliary Machinery for Rolling Mills.—Auxiliary machinery for rolling mills comprising machines for overhauling, slab milling, sawdust drying-out, acid cleaning, scratch brushing and coiling are described in a catalogue issued by Messrs. W. H. A. Robertson and Co., Limited, Bedford, who build these machines to designs supplied by an American firm.

Electrical Plant and Fittings.—A handsome catalogue of electric generators, light fittings and fans is to hand from Messrs. J. Stone and Co., Limited, Deptford, London, S.E. 14. Five types of generators are illustrated in detail, all the component parts being numbered and coded for telegraphic ordering. The light fittings are of convenient and artistic design.

Mill Plant, &c.—Pumping and hydraulic machinery, winding engines, hauling gear, grinding and crushing mills, mixing, sifting and similar machines, together with heavy chemical and mill plant are dealt with in a catalogue received from Messrs. Pratchitt Brothers, Carlisle. Illustrations of many of these are given with dimension tables of standard sizes.

Electric Lifts.—A handsome catalogue fully describing and illustrating their electric lifts has come to hand from Messrs. William Wadsworth and Sons, Limited, Bolton. The winding, control, safety and other gear for passenger goods, vehicle, cupola and other lifts are clearly dealt with, and a useful table of working costs based on records of actual running is also included.

Refrigeration Fittings.—In marine refrigerating installations a certain amount of brine may accumulate between the hatch grid cocks and the coaming cocks, and although the quantity is small it may damage the cargo when the grid is disconnected. Mr. William A. Harper, 41, Kingley-road, Wallasey, sends a catalogue of a non-drip connection which he makes to avoid this fault.

EFFECT OF HYDROGEN ON COPPER.—In 1902 Heyn observed that hydrogen had a deleterious effect on some copper which on examination was found to contain some cuprous oxide. A case of this kind came before the Materialprüfungsamt at Berlin-Dahlem last summer and was investigated by O. Bauer and Vollenbruch. The specimen was a stout copper wire, some portions of which were cracked on one side; when the wire was bent, the cracks opened out, so that the cross-section of the wire showed a series of serrations. It was ascertained that the gas in which the copper ingot had been heated for rolling was rich in hydrogen, and it is suggested that this gas had had access on one side to the copper, the oxide of which it locally reduced; the water vapour formed by this reduction cracked the surface when escaping. Copper should not be directly heated in reducing gas, but placed in closed furnaces heated from outside.

SOLUBILITY OF GASES IN ALUMINIUM.—In studying the solubility of various gases in aluminium, J. Czochralski (*Zeitschrift für Metallkunde*) passed streams of gases over aluminium, heated in a furnace, experimenting with about 200 grammes of Al at a time. He determined the absorption of a gas by the change in the density of the metal and by chemical analysis; the relative volumes of the visible gas enclosures were also measured. He found that very little gas was taken up by hot aluminium, so long as the temperature did not exceed 900 deg. C. Up to 3 per cent. of nitrogen were taken up between 900 deg. and 1,500 deg. C.; oxygen proved more soluble than nitrogen, and hydrogen most soluble of all the gases tried, up to 15 per cent. by volume of hydrogen being taken up by the metal. The order of increasing solubility was: Nitrogen, carbon monoxide, air, oxygen, sulphur dioxide, carbon dioxide, coal gas, hydrogen; the coal gas used contained about 40 per cent. of hydrogen.

THE UTILISATION OF EXHAUST HEAT FROM INTERNAL-COMBUSTION ENGINES.—The subject of the utilisation of the waste heat from internal-combustion engines for the purpose of generating steam is one which is receiving increased attention. With the ever-increasing number of motor ships being put into commission, and the gradual tendency for increased powers, the reduction of the loss due to exhaust gases becomes of greater moment. Messrs. Spencer Bonecourt, Limited, have undertaken a considerable amount of work in this direction, and interesting particulars are given in a paper which was read some time ago before the Association of Engineers-in-Charge by Major W. Gregson, B.Sc. Undoubtedly it is in the marine field that the application of such types of boilers will find its fullest scope, since for such duties as heating the ship and operating the steering gear when at sea, the utilisation of the heat of the exhaust gases for raising steam, if it can be carried out without the upkeep of the steam generator being disproportionately costly, will assuredly prove to be the system widely adopted in the future.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

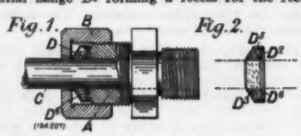
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

HYDRAULIC MACHINERY.

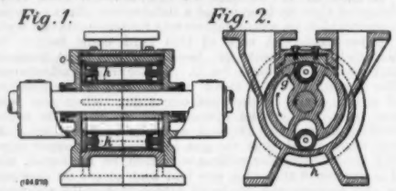
184,287. K. Rotherham, Coventry, and A. E. Eyles, Coventry. Pipe Unions. (3 *Figs.*) May 17, 1921.—The invention relates to pipe unions of the type in which packing is compressed around the tube and also against an annular rib on the union body. According to the invention, the packing member D comprises a metal casing formed of two parts D^3, D^4, one of which, D^4, is dished and provided with a circumferential flange D^6 forming a recess for the reception of



asbestos or like fibrous material D^2, and also for an annular disc D^6 constituting the other part of the casing, which encloses the asbestos therein and itself is secured by bending over the edge of the circumferential flange. The union body is shown at A, the union nut at B, and the pipe at C. The pipe C is pushed into the hole in the union body for a sufficient distance to support the pipe, and is then sealed by clamping the packing member D between the union nut and the end face of the body. (*Sealed.*)

PUMPS.

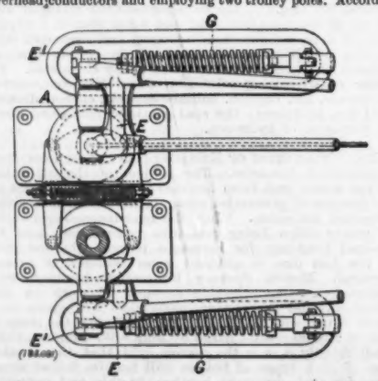
184,873. J. A. Mair, Greenock, and A. C. Cairns, Greenock. Rotary Pumps. (4 *Figs.*) May 20, 1921.—The invention relates to rotary pumps of the type having a drum-shaped rotor with radially-sliding members (commonly termed vanes) which press against the interior surface of a cylindrical casing within which the rotor revolves, the casing being provided with an admission port and a discharge port, and the fluid (which is being pumped) being carried from the admission port to the discharge port in compartments enclosed by the exterior surface of the rotor, the interior surface of the



casing and two consecutive "vanes." This invention consists in a construction of pump of the type in which the "vanes" A consist of rollers located in radial recesses or slots *g* in the rotor, the invention being characterised by the fact that each roller A is kept completely out of contact with the forward side of its slot, is restrained from pressing on the rearward side of the slot, and is enabled to roll freely on the inside surface of the casing, by the provision of discs or wheels *o* mounted at the ends of the rollers and engaging with the side of the slot at the ends thereof. (*Accepted September* 6, 1922.)

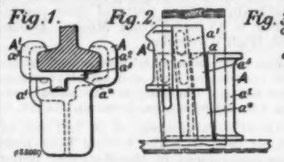
RAILWAYS AND TRAMWAYS.

185,031. E. M. Munro, London. Trolley Pole Sockets or Bases. (5 *Figs.*) September 19, 1921.—This invention relates to the sockets or bases for trolley-poles for electrically-propelled vehicles, and has particular reference to a base intended primarily for use on railless vehicles taking power from two overhead conductors and employing two trolley poles. According



to the invention, the elevating spring G for each pole is mounted so that it lies outside the vertical plane of the pole, and on the side remote from the other pole. Preferably each pole is mounted in a socket E rotatable about a horizontal axis on a table A forming part of a base which can rotate about a vertical axis, the stationary part of this base being mounted on the roof of the vehicle. The outside end of each socket E has a lug or extension E^1 acting as a crank arm, and on this arm the elevating spring G acts. The elevating spring may conveniently lie in a horizontal plane and extend forward in a vertical plane parallel to the vertical plane in which the trolley pole moves. (*Sealed.*)

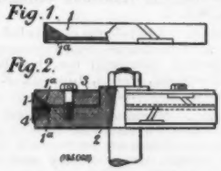
185,061. L. P. Winby, London. Permanent Way. (4 *Figs.*) January 10, 1922.—The invention relates to devices for preventing the creeping of the rails of permanent ways. The invention provides a device applicable to "bull headed rails." A, A^1 are the two portions of the device, the member A (the "clip") having an inclined slot *a* serving for the reception of the projection a^1 on the member A^1 (the "mate"). The rail base is engaged by lugs or clips a^2, a^3 on the members A, A^1, respectively. The member A is formed with a stepped portion a^4, the upstanding wall of which may be inclined relatively to the clip portion a^2 similarly to the walls of the slot or



groove *a*. The member A^1 has an extension or projection a^5 adapted to rest on or fit over the stepped portion a^4 of the member A, the end a^6 of the extension a^5 having an inclination corresponding with that of the projection a^1. When the parts are assembled a flat surface is formed upon which the rail base rests, and by reason of the provision of the extension a^5 any tendency of the member A^1 to tilt backwards away from the rail is prevented. When the device is in position any tendency to creeping action of the rail will be opposed by the binding of the projection a^1 against the walls of the slot *a*, since when the rail starts to creep the member A is forced toward the member A^1, resulting in the grip on the rail being tightened. (*Sealed.*)

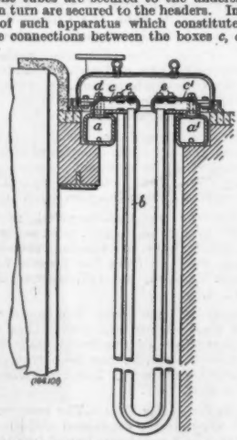
STEAM ENGINES, BOILERS, EVAPORATORS, ETC.

185,003. W. G. Kelso, Belfast. Piston Rings. (3 *Figs.*) August 11, 1921.—The invention relates to that type of piston packing comprising bevelled or tapered rings so arranged in a correspondingly shaped groove in the piston as to be forced out against the cylinder wall by means of a spring. The invention consists of a piston packing of this type characterised by the employment of split packing rings having portions of the abutting faces of the rings cut away to provide an annular recess for the reception of the spring which normally forces the rings axially apart so that they maintain close contact with



the adjacent walls of the ring groove formed in the piston. Each ring 1 is bevelled or tapered on the inside as shown in section at Fig. 1, so that the depth is greater at the outer side than at the inner side, and the flat face of the ring is cut away or recessed as at $1a$. Two rings 1, 1 are fitted together between the piston 2 and a junk ring 3, the adjacent faces of the piston and the junk ring being correspondingly bevelled to suit the packing rings, and the spring 4 is arranged in the annular recess formed by the cut-away portions $1a$, $1a$. The spring 4 normally forces the packing rings 1, 1 axially apart against the bevelled faces of the piston 2 and junk ring 3. (*Sealed.*)

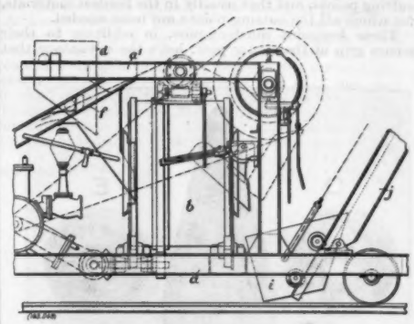
184,101. Galloways, Limited, Manchester, and H. Ashton, Hyde. Steam Superheaters. (3 *Figs.*) October 24, 1921.—The invention relates to steam superheaters of the type having U-shaped tubes connecting two parallel headers in which the ends of the tubes are secured to the undersides of hollow boxes which in turn are secured to the headers. In the improved construction of such apparatus which constitutes the present invention, the connections between the boxes *c*, c^1 and headers



a, a^1 are effected through the upper walls of the latter to which the boxes are secured, the superheater tubes *b* being expanded into the under walls of the boxes *c*, c^1, which are offset to project beyond the inner side walls of the boxes *a*, a^1 sufficiently for this purpose. This construction enables free access to the ends of the superheater tubes without interference or obstruction from the affixing bolts *d* of the boxes by providing screw plugs *e* in the upper walls of the offset boxes or chambers opposite the ends of the tubes. (*Sealed.*)

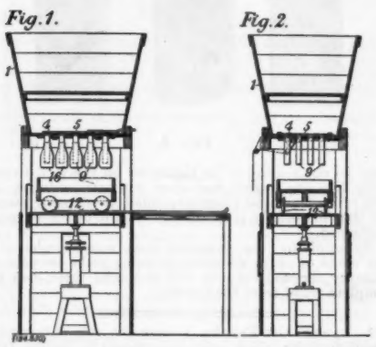
MISCELLANEOUS.

183,548. J. W. Davison, Pontypridd, and H. Bramwell, Llantrisant. Concrete Mixing Machines. (3 *Figs.*) April 21, 1921.—The invention relates to concrete-mixing machines, more especially intended for arching in the underground roadways of collieries. According to the invention, concrete mixing apparatus comprises an underframe *a* adapted to run on rails and having mounted upon it a rotary concrete mixer *b* driven by a motor. The frame *a* carries a superstructure a^1 comprising rails *f*, upon which a charging skip *d* may be drawn up from a low position convenient for being charged from a colliery tram into a position in which its contents may be discharged into the mixer. Pivotally supported upon the frame *a* is a jib *j*, which is also provided with rails upon which another skip *i* may run from a position at the lower end



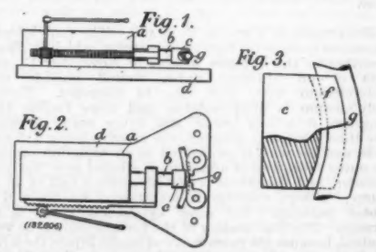
of the jib *j* convenient for being charged from the mixer to a position near the upper end of the jib where the contents may be discharged. The superstructure is adapted for the reception of a water tank from which water may be supplied to the mixer and for the reception of winches respectively provided for raising and lowering the skips *d*, *i*, and for adjusting the inclination of the jib *j* according to the position at which the concrete is to be delivered. The respective winches and controlling levers are arranged to be operated by one man from one side of the apparatus. (*Sealed.*)

184,850. B. A. Oldham, Denton, Manchester, and J. W. H. Rawdings, Dukinfield. Delivering Measured Quantities of Substances. (3 *Figs.*) May 17, 1921.—The invention has reference to apparatus for delivering measured quantities of granulated or pulverised substances into bags, of the kind comprising a number of measuring tubes of predetermined capacity having their inlet ends connected with a source of supply and their lower ends adapted to be closed during filling by pressing against them the bottoms of the bags. Apparatus according to the invention comprises a hopper 1 for the substance, having its bottom provided with a number



of holes or openings 4 adapted to be opened or closed by a slide 5, a corresponding number of measuring tubes 9 mounted below the bottom of the hopper 1 in alignment with the holes or openings 4 and a vertically reciprocating table 12 for the support of the bags 16, the table being adapted to be raised to press the bottoms of the bags against the lower ends of the measuring tubes to close same during the filling thereof, and to recede, after the filling of the tubes and the cutting-off of same by the slide 5 from the supply, to allow the measured quantities to pass from the tubes into the bags. (*Accepted September*, 6, 1922.)

182,606. D. Mc.N. Tarbet, Glasgow. Bending Copper Pipes. (4 *Figs.*) December 21, 1921.—This invention has reference to appliances for bending or curving copper pipes or tubes. According to the invention, a die or former is employed and is so shaped that during the bending operation it engages the external diameter of the pipe. The die is operated upon only at nearly diametrically opposite points and thereby prevents or



lessens distortion of the pipe. *a* is the cylinder, *b* the ram and *c* the die or former operated on by the ram. The cylinder is mounted on a base *d* having two stops. As clearly shown in Fig. 3 the die is formed with outward extending jaws *f* which grip the pipe *g* when the latter is being bent. In operation, the pipe *g* is inserted between the stops and the die *c* and the ram subjected to pressure. (*Sealed.*)